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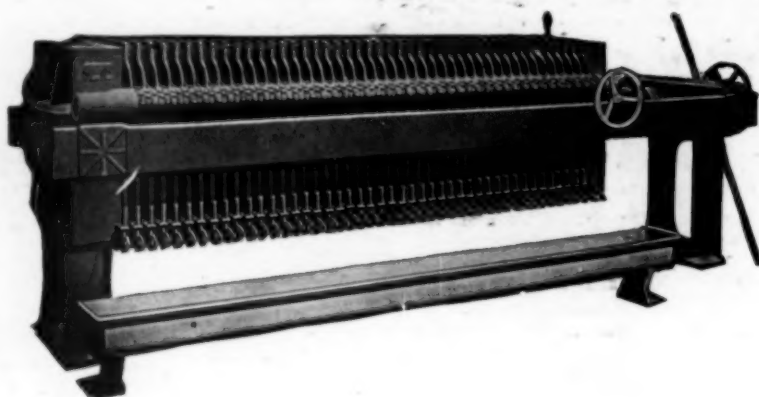
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# CHEMICAL & METALLURGICAL ENGINEERING

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## Naval Influence in Abolishing Chemical Warfare

NEWS from Washington is gradually illuminating the report of the Advisory Committee to the Disarmament Conference recommending the abolition of chemical warfare. This report has always been more or less of a mystery to us because we knew that the Advisory Committee numbered among its members such men as General PERSHING, Secretary HOOVER, Senator SUTHERLAND and Governor PARKER of Louisiana. We felt that the favorable influence of General PERSHING could be counted upon, because he went on record strongly before the House Committee on Military Affairs in favor of the establishment of a chemical warfare division of the Army. The other members named we knew to have sane views on the impracticability of outlawing chemical warfare, although we felt that they might be too busy to give the subject much attention. Hence it was with surprise that we heard the first rumor that the Advisory Committee had resolved to recommend abolition of gas warfare. Rumors have also been afloat to the effect that the report was railroaded through the committee, and some color is lent to this statement from the fact that after the report was first submitted to Secretary HUGHES it is said to have been recalled for further consideration.

It appears now that friends of the battleship exercised considerable influence with the Advisory Committee and helped to determine its action. This is unfortunate, if true, because the Navy stands as a prejudiced party when chemical warfare is under consideration. Ever since it was demonstrated last summer that capital ships were likely to prove no match for a combination of chemical warfare and the aviation service, the Navy has shown animosity toward gas warfare. But our objection lies deeper than this. Comparatively speaking, the Navy knows little about chemistry—far less than the Army. The latter has made great strides in the application of chemistry in the solution of its problems and it appreciates chemists and their services. In these two respects the Navy has shown few signs of progress and some evidence of a reactionary spirit. Its chemists are on a per diem basis and are classified with “clerical, drafting, inspection, watchmen and messenger service.”

Viewed in this light, it is hardly fair, as reported, that naval influence should be powerful enough with the Advisory Committee to influence its action. We have already expressed our feeling that the Disarmament Conference made a mistake in adopting this resolution, and we still express the hope that when the time comes for ratification of treaties the Senate may be persuaded to dissent.

It may be argued that the Advisory Committee can take refuge in the results of its survey to discover popular opinion on the questions brought before the Dis-

armament Conference. The statistics are interesting, indeed startling, but in our judgment they are without practical value. They are utterly discordant and irrelevant and show no constructive thought. There is evidence of voting by organizations and societies, many of which may have had predetermined partisan purposes. Thus while only 220,896 actual signatures were received, there was a vote of 1,093,535 for an association of nations. For open sessions of the Conference there were 1,056,499 votes; and we know that open sessions as popularly conceived were impracticable. Only 5,499 thought that Far Eastern questions should be considered, and yet these were of the utmost importance in their influence for war or peace within the next generation. As many as 395,104 votes favored abolition of submarines, but the Conference merely limited their use in warfare and did not abolish them. So we are not impressed with a vote of 366,795 for abolition of gas warfare. The figures merely reflect uninformed opinion on the part of a selected group.

## Will the Industries Absorb Chemical Graduates?

IN HIS recent speech before the Chicago Section of the A.C.S., Dr. JOHN JOHNSON of Yale University stated that the electrical industry is the only industry in the United States well supplied with technically trained men in executive positions. While he did not enlarge upon this comparison of the electrical industry with the chemical and process industries, it may be advantageous to study the personnel conditions in each field.

About 20 years ago, when the electrical industry was in the more scientific stage of development and many questions of technology were being settled, involving need for research in physics, electrochemistry and new engineering design, men like STEINMETZ, EDISON and WHITNEY received much publicity about their accomplishments. Electricity was coming into wider use, and construction and operating men were becoming known for their work over the whole country. As a consequence there was a rush on the part of high school graduates to our universities demanding education in this field so fertile for individual progress. When they began to finish courses in electrical engineering the profession was thought to be overcrowded. It was in fact so far as opportunities for pure engineering were concerned, for the standards of design were rapidly being established.

The industrial folks, however, were not found sleeping. Taking cognizance of the situation, such manufacturers as the General Electric Co., the Westinghouse Co. and, in the public utility field, the Cities Service Co., arranged to take graduates into their testing departments where pure engineering with study of apparatus is involved. Here at the rate of hundreds per year they were

gradually educated to appreciate the many phases of the electrical business and finally tempted into production, sales and management. They were allowed to choose the branch most suited to individual temperament.

Not a few remained active in the pure engineering phase of the work, but the majority by reason of birth and home training found a natural taste for the business phases. As a result the industry has become saturated with technically trained men. The manufacturers naturally welcome the final graduation from the manufacturing side and the entry of these men into public utility service as managers and operating chiefs with customer companies. While the manufacturer has turned a deserved business advantage for himself, he has by the same policy performed a great service to the electrical industry.

The chemical industries are now in a position approximating that of the electrical industry when the education of the student for the field was undertaken. Many chemically trained men are coming through the universities each year. The chemical industries, including manufacturers of fine and heavy chemicals, coal-tar products, dyes, explosives, electrochemical products, fertilizers, alcohol, etc., must take these men and turn them into paths where they are greatly needed.

Nor may the manufacturer stop by obtaining men for his own particular work. He should turn out men for his customers, the process industries where chemical control is essential. For the makers of animal products, plant products, soap, sugar, food products, leather, paper, etc., including about twenty major fields, are the customers of the chemical manufacturer and in some cases must be educated to the consideration of technology.

No one is better suited to do this work and can profit more in the doing than the manufacturer of chemicals. The greatest good may come to American business if these graduate chemists be saved from throwing over their profession in disgust.

#### Coal and Coke In 1921

THE first weekly report on coal production from the United States Geological Survey for this calendar year is of particular interest because it gives preliminary estimates of the production of bituminous coal, anthracite coal and beehive coke for the year 1921. These figures for coal indicate just what one would expect—namely, that the production of bituminous coal has been very low, in fact distinctly lower than any previous year since 1911. This is a natural result of the depressed business conditions of the period, and it would have been possible only under such conditions. As would be expected, the anthracite production has been about the same as for the decade past, since this coal represents principally domestic fuel demands and is largely unaffected by business conditions of the country.

The total coke production of the country is estimated as approximately 26,000,000 tons—in other words, much less than during the previous ten-year period, but a large proportion of the decrease from the years immediately preceding was caused by the decrease in beehive and the relatively small part of the decrease was caused by the diminution in byproduct coke output, large though this latter decrease was.

The most encouraging point in the year's summary is the fact that it was primarily the output of beehive coke

which was so much lower than for many years past. In fact it decreased by 74 per cent from the output of 1920, and was only about one-seventh of that of 1916, during which year the beehive coke industry reached "the high point of prosperity." To find a year when production was as low as during 1921 one must go back to 1885, when practically the same quantity of beehive coke was produced—namely, a trifle over 5,000,000 tons.

It is a splendid condition of industry that permits the fluctuation thus to occur almost altogether in the wasteful and inefficient branch of industry and permits the more efficient portion to continue to function at higher rates despite the decrease in total business.

#### Speaking Of Thrift

THIS week we celebrate the anniversary of BENJAMIN FRANKLIN's birth, and we are all urged to give consideration to the cultivation of habits of thrift. Why is it that when anybody tells us to save our money we resent it. Of course, we want everybody to understand that we know how to manage our own affairs, whether we do or not, but we are especially sensitive to advice about saving. Indeed, the more we need to save the less we like to hear about it. We like to think, and indeed the less intelligent of our number continually do cry, that to save is a virtue that the very stupidest may practice. Then, when our wits have left us entirely, we like to chuckle over the idea that rules for dullards do not apply to us.

We venture the belief that the fault is in the capsule and not in the medicine. We should save; it is a good thing to do it, and it is bad for us as well as for the general welfare to waste our substance; to throw away uselessly what we have earned. It should not be an offense to urge us to save. It does not offend to urge us to read philosophy or history, for instance. If someone says of SUMNER'S "Folkways," "It is hard reading, but meaty; you will enjoy it," it flatters our vanity; it indicates that we can understand what others cannot. Then why not appeal to vanity or at least to self-respect in urging people to save?

Consider the Hearst newspapers, edited for the lowest orders of intellect that can read at all. And yet the billboards declare that, for instance, the New York American is "A Newspaper for Men Who Think." A glance at the physiognomies of the readers of the Hearst newspapers in street cars discourages belief in the statement—but not among the readers. They think they think. Everyone thinks he thinks.

Now the facts about saving do not coincide with the usual advice. The ability to save is not as common as dirt. It takes intelligence to save, and to be able to do so is a gift. Whoever can practice the art may be stupid in regard to descriptive geometry or physical chemistry or the music of such modern composers as MAX REGER, or SCHOENBERG, but he is not feeble minded in regard to saving. We are all feeble minded in one respect or another, but the all-round feeble-minded person cannot save. And yet so much emphasis has been laid on the thrifty dunderhead that the impression has gained ground that only the imbecile are provident.

The idea is totally wrong. The half-wit may hoard a few dollars from some remaining instinct that he cannot explain, but in ninety-nine cases out of a hundred it is soon wasted. It takes long-range vision to save. It does not call for self-denial or Pollyanna goodness. It calls for a look ahead long enough to see between a

present fancy and a greater purpose. It calls for ability and character and a certain sporty quality to stick to a purpose. If we want to refer to persons who work with their hands or who do not wear expensive clothes as "the plain people," why not discriminate between those who can save and those who cannot? They are different. The savers are better and more able in this respect, and they deserve credit for it. Why not give it to them? They will respond, and many of them will even read "Folkways." Then, when they have read that book, they will not read yellow newspapers that strive to make their readers angry in order to keep their attention. The savers will prefer constructive literature that induces human progress.

### The Distribution Of Steel Consumption

A STUDY of the greatly varying rate at which steel has been produced in the past 13 or 14 months and of the accumulation and liquidation of stocks of steel and of manufactured goods made from steel indicates that there has probably been but slight variation in the rate of actual ultimate consumption of steel since the collapse of the high-pressure demand in the steel market late in 1920. Such a conclusion is reassuring both to the steel-making industry and to business generally. When, last July, the production of steel ingots dropped to a rate just one-fourth the average rate in the first 9 months of 1920, the steel makers were more or less alarmed. Before the war there had been a tradition, supported by actual experience, that the "hard times" or irreducible minimum of steel demand was fairly definite, commonly designated as 50 per cent of capacity.

Without going into details, it may be stated that without any strain of the imagination it can be conceived that the ultimate consumption of steel and steel products has been fairly uniform since late in 1920. The steel consumed is represented by a steel ingot production at the rate of 22,000,000 tons a year, which is the rate at which steel was produced during the last 3 months of 1921. The theory before the war was that it required a certain amount of steel simply to keep the country going, while whenever the country was expanding its facilities, a great deal more steel would be required, for almost any kind of industrial or commercial expansion involves putting steel into employment, chiefly in what is called "investment construction."

Unfortunately it is impossible, except by an amount of work that nobody seems willing to undertake, to make an exact analysis, either for a year or a period of years, of where the steel we make actually goes for the purpose of performing its ultimate service, but rough approximations are by no means difficult. Certain lines of consumption are seen to be relatively stable. Judged by present prospects and by the actual record of the past half dozen years, the largest steady customer of the steel industry is the oil trade. For maintaining the production of petroleum about a million gross tons annually of steel tubular goods is required, with considerable quantities of other steel, particularly of plates for storage tanks. Apparently insignificant from the tonnage standpoint, tin plate can be counted upon to involve about one and a half million gross tons. There have been two "off" years recently in tin plate—1919 on account of stocks of about 8,000,000 boxes on Nov. 1; 1918 a safeguard in connection with the war, and 1921 on account of stocks of prepared goods which the public would not buy at the prices originally asked. The auto-

mobile industry is a steadier consumer of steel than is commonly supposed. It is not generally realized that beginning with 1916 the production of passenger automobiles other than Fords has not varied very greatly and has not materially increased. The production of Fords has increased sharply. The consumption of rolled steel in automobile building is, however, scarcely 750,000 gross tons a year, so this is a minor item compared with tin plate or the steel used by the petroleum industry.

The cases mentioned above are of regular consumption, merely that the country may keep going. In many lines both upkeep and expansion are involved. In railroading, for instance, it requires about 1,500,000 tons of rails a year for replacements, while additional rails are required when new track is laid.

The year 1921 furnished a crucial test. There was very little steel consumed that did not absolutely have to be consumed, and the steel industry is now furnished with a measure of the amount of backlog business it can count on with practical certainty, this to be added to by such expansion and progress as financial and commercial conditions may warrant from time to time.

### Omnia Mutantur

#### Nos et Mutamur in Illis

LATELY we saw a note made by Dr. CHARLES BASKERVILLE in his diary at the Pittsburgh meeting of the American Chemical Society in 1902. Dr. IRA REMSEN was in the chair as president, and Dr. THEODORE W. RICHARDS had presented a paper on "The Compressibility of the Atom." As soon as he sat down "a very well-dressed chap arose and said, 'I have a machine here with which you may see the millions of atoms in rapid motion.' REMSEN promptly declared, 'There being no discussion of the paper, I shall call on — [the author of the next paper on the program] for his communication.' The individual referred to slapped the top down, picked up his books, jammed his hat upon his head, and marched off in a huff. REMSEN then remarked: 'I must apologize to the Society for my abrupt method of shutting off discussion of Professor RICHARDS' excellent paper, but subsequent events apparently have verified my diagnosis.'"

In the margin was a note made by the diarist many years afterward: "Could this have been an ultra-microscope, and was R's mind closed to such a conception?" Maybe so; maybe so. But were not the minds of most of us closed to such a conception—only 19 years ago? We should also like to know who the "well-dressed chap" was. We can think of one who might have been he who thought he had a machine in which he could see atoms—and may really have had it—but the fact that the person was well dressed rules out our candidate.

Without question we are living in darkness even today. What is, then, the specific feature of our ignorance that hides the light from us? Is it because we know so little of isotopes? Is it because we lack the shepherd's art of herding electrons? Or because our sense of positive electric charges is so hazy? Will IRVING LANGMUIR rob us of our benzene ring?

Without a doubt both you and I  
Will be regarded, by and by,  
As very odd and very queer  
By all the people living here.

Old and archaic we shall be;  
They'll say we lived so curiously.  
They'll wonder at our negligence  
And why we hadn't better sense.

## Perkin Medal Is Presented to William M. Burton

The Discoverer of the Burton Process of Cracking Petroleum Distillates Receives the Fifteenth Award of the Society of Chemical Industry—Addresses by Officers and Prominent Members of the Society—Presentation by C. F. Chandler and Acceptance Address of William M. Burton

**P**RESENTATION of the fifteenth Perkin Medal to be awarded by the American Section of the Society of Chemical Industry for meritorious accomplishments in applied chemistry took place in Rumford Hall, New York City, on Friday, Jan. 13. The medalist was William M. Burton, president of the Standard Oil Co. of Indiana and famous for the discovery and large-scale development of the Burton process of cracking petroleum distillates. Seldom, if ever, in the history of the Society has the Perkin Medal been awarded under such auspicious circumstances nor to an investigator whose work has so profoundly affected one of the country's great industries.

In the course of his introductory remarks the chairman, Sumner R. Church, called attention to the distinguished presence of all of the four past presidents of the American section. With considerable regret, however, he announced that Dr. R. F. Ruttan, present head of the Society of Chemical Industry, had been prevented from attending the presentation meeting because of a severe physical disability.

### REMINISCENCES BY DR. REMSEN

The first speaker to be introduced was Prof. Ira Remsen, often called the "father of chemistry in America." In his characteristic manner he gave a most interesting and intimate insight into the life and work of Dr. Burton. He recounted many personal reminiscences of his early association with his former student who was then continuing his graduate studies in the laboratories of Johns Hopkins. The investigations at that time were into the realms of pure science and, with his usual good-natured humor, Dr. Remsen chided the medalist for deserting the rôle of the scientist and entering into the executive side of industry.

The formal addresses of the other speakers are presented, either in full or in abstracted form, in the following pages.

### The Personal Side of Dr. Burton

BY CHARLES H. HERTY

The charm of biography persists always. The results of a successful man's work are set forth in the public record, whether it be in the form of scientific publications, of official status, of some great engineering feat, of the size of his income tax, or what not. Back of the life accomplishment, however, is the personality of a human being who, following the bent of his own genius, has triumphed over the difficulties which beset us all.

What manner of man did it? That is the question which kindles a different kind of interest from that due to a knowledge of what the accomplishment is. For out of such studies of many types of men we gain here and there suggestions, self-applicable, which help us over our own rough spots and give us hope.

In the case of Dr. Burton, or "Billy," as he was called by us in student days at Johns Hopkins Univer-

sity, there is added another to the long list of successful men who were born in the country and passed their early days entirely ignorant of cement sidewalks. What a pity we couldn't all have persuaded our parents to move out to the country before we were born. At any rate, it was Billy's good luck to enter the world under such favoring circumstances in the year 1865. In 1886 he was graduated from Western Reserve University, receiving the A.B. degree. The next 3 years were spent at Johns Hopkins University, from which institution in 1889 he received the Ph.D. degree.

### A NORMAL INDIVIDUAL

It is peculiarly fitting that the Perkin Medal should be awarded to him in this the first year of President Harding's administration, for right well does he represent the return to normalcy, all of his friends to whom I have written emphasizing the fact that from boyhood to the present time he has always been a normal individual. He has cultivated no particular hobby, considered by many to be essential to distinction, but has carried through life a love of experiment and an ardent zest for the lathe and mechanical tools. It is easy to understand, therefore, that in the environment in which he has worked he not only succeeded in cracking oil but carried the work on to a successful large-scale application.

He plays no outdoor games, not even golf. This sounds abnormal, but to offset it he recently obtained keenest satisfaction in installing in his home under his personal direction a radiator system at one-fifth the estimate furnished by a contractor, and who wouldn't rejoice at getting the best of a plumber? I insist he is normal.

### THE SIGNIFICANCE OF HIS SUCCESS

Steadily he has been advanced in that company with which he began work after completing his university training, until today he occupies the presidency. Throughout this advancement he has remained the same sincere, sympathetic, level-headed man to whom his friends and associates come with their problems for his sound advice.

That he has worthily won this great honor from his associates in business all agree, that throughout it all he has preserved his unaffected selflessness all will rejoice; but there is another aspect of his success which deserves not only record here but wide heralding at this stage in the development of American chemical industries. The industry with which he is connected is one of our early and now thoroughly stabilized industries, and it is peculiarly worthy of note that the Standard Oil Company of Indiana has chosen for its chief executive the chemist. Not all chemists are qualified to be executives, but certainly our chemical industries will be placed on a much sounder basis when the chemist of proper qualifications is given opportunity to share in the determination of corporate policies. Billy Burton's record may yet prove the harbinger of a new day.

### The Chemist in Industry

Dr. Burton's monumental work in the oil industry was fittingly reviewed by one of his associates, Russell Wiles, patent adviser of the Standard Oil Company of Indiana, who chose for the subject of his address "The Chemist in Industry." It is only within the last few years, he declared, that the chemist has contributed his proper share to industrial progress. "Much has been done in chemistry as a pure science, but it is within comparatively recent years that the chemist has emerged from his laboratory and that industry, as a whole, has felt the need of close co-operation with him. Where 10 years ago big practical applications of chemistry were rare or confined to a few specialized industries, today there is scarcely an industry which has not been more or less affected by the progress of chemical science. Chemical inventions, at least as exemplified in my own practice, are at least ten times as numerous as they were a decade ago.

"The work of Dr. Burton, which is being so fittingly recognized, may well be regarded as rather an early example of the great things the chemist is to accomplish in the future than as an achievement which is to be unique in history. Bringing a thoroughly scientific point of view and applying to his problems the methods of pure science, with his great natural ability and indefatigable industry, it was entirely unavoidable that Dr. Burton should profoundly affect the petroleum industry in one way if not in another. No man has ever had a more promising field—an enormous industry dealing with problems which ought to be handled in an essentially chemical manner and having no chemists at all. Dr. Burton would be the first to recognize his splendid opportunity, and it is characteristic of him that his opportunity never was neglected.

#### PRODUCTION ON A SCIENTIFIC BASIS

"But Dr. Burton alone never could have accomplished what has been done by the Standard Oil Co. of Indiana. There has been much discussion in big corporations as to the best method of correlating the scientific force with the manufacturing force. All sorts of experiments have been attempted and all sorts of systems have been devised. The system worked out by the Standard Oil Co. of Indiana, largely at the instigation of Dr. Burton and of recent years under his guidance, is unique and amazingly successful. None but a scientifically trained man would have dreamed of such a system and the operations of the Indiana company are the best demonstration of the industrial value of scientific training.

"The system of this company is founded on the premise that a scientifically trained man is a good man for any job; the scientific staff does not co-operate with the manufacturing staff—it has become the manufacturing staff. The practice, so far as concerns chemists, has been to take on trained men for the laboratory force precisely as in many other plants. After brief association with the laboratory, during which the newcomer can become familiar with the peculiar problems of the works and particularly of some special department to whose problems he is assigned, he leaves the laboratory and goes into the works in some subordinate capacity. It then becomes his prime duty to test, on a practical scale, whatever improvements may fall within the sphere of his department. Having once become established in the works, it has been found that almost without exception the technical men become excellent executives and their promotion is rapid.

"The result is that the manufacturing department of the Standard Oil Co. not only maintains an excellent research department, but that the whole manufacturing organization from top to bottom is largely dominated and controlled by men of scientific training. The Standard Oil Co. of Indiana is unique in this regard, and the tremendous success of its manufacturing department must be very largely attributed to the superb organization which Dr. Burton conceived and has built."

#### THE BURTON PROCESS

After showing how thoroughly this system has been applied in the Whiting refinery, which is the largest plant of the company, Mr. Wiles turned his attention to the industrial significance of the Burton process.

"No industry was ever so profoundly modified by any process as the oil business has been modified by this process. How profoundly the Burton process has affected the refining practice in plants where it is in full operation can never be thoroughly comprehended by one outside of the industry. There are, however, some points which might be overlooked which are illustrative.

"The Burton process has more than doubled the yield of gasoline from a given quantity of crude run. Practically, this means that a given quantity of crude oil supplies twice as many engines with fuel. But these engines have to be lubricated, the cars they propel have to be provided with grease, and the very road surfaces upon which they run have to be provided with asphalt. The increased supply of gasoline has enormously increased the demand for these other products, and, at the same time, the normal increase in demand for other petroleum products, such as wax, petroleum jelly, etc., has been greatly augmented, as might be expected with the increase in population.

"The problem of finding the increased supplies of all these commodities, when more than twice as much of the crude oil run is going into gasoline, has been extremely serious. Indeed, at times, some oil refineries have been essentially on a lubricant basis—i.e., the amount of crude run was determined primarily by the lubricants demand instead of the gasoline demand, but the ingenuity of the scientific staff has proved itself entirely equal to the problem. Running methods throughout the plants have become modified in one way and another to produce all the needed products in quantities so balanced as to meet the market demands, but the practical working out of the Burton process by no means has consisted in setting up the Burton stills and running them as a side line or excrescence of the refinery. The entire operation of the refinery has had to be readjusted fundamentally to co-operate with the pressure still plant.

"And it may be added that the profound shift in the ratio in which products are being produced and the practical withdrawal by the Standard Oil Co. of Indiana of gas and fuel oil from the market has very profoundly modified marketing methods. The full extent to which the changes in marketing methods, largely caused by the existence of the Burton process, may affect this and other industries in the future is problematical. The new problem was met satisfactorily but in a manner which may have far-reaching future consequences."

In concluding his address, Mr. Wiles paid tribute to his associate in the following words: "In extending to William M. Burton this highest honor in your power, you honor one who has brought honor and credit to your profession, a scientist of scholarly ideals and high at-

tainments, an organizer of broad vision and confident faith in the future, an efficient and successful executive and, perhaps greatest of all, a leader of men. Dr. Burton asks nothing of his men which he is not capable of doing himself. His greatest tribute, greater far than any award for scientific attainments, is the affectionate regard of those with whom he has worked for so many years and who know him best. Our greatest rewards are not degrees, or diplomas, medals or decorations, but the esteem and affection of our associates. These Dr. Burton has long had in abundant measure.

"But in honoring him you celebrate a great achievement of your own great profession. May this be only one of a host of like achievements which you have reason to recognize. May these awards, from year to year, mark equally great gifts to human knowledge and human comfort. The day of the chemist is here. You hold the future of industry."

### Presentation Address

BY C. F. CHANDLER

It is my privilege and very pleasant duty, as senior past-president of the Society of Chemical Industry residing in this country, to present to William Meriam Burton, A.B. and Ph.D., this fifteenth impression of the Perkin Medal, in recognition of his most original and valuable work in applied chemistry.

Dr. Burton was born at Cleveland, Ohio, on Nov. 17, 1865. He was graduated at the Western Reserve University in 1886 with the degree of A.B. Subsequently he attended the Johns Hopkins University, taking the major course in chemistry under Prof. Ira Remsen, receiving the degree of Ph.D. in 1889. His papers published at this time in the *American Chemical Journal* attracted favorable attention in scientific circles.

Soon after graduating he was engaged as chemist, in 1889, by the Standard Oil Co. at Cleveland, Ohio, to assist in a process for refining the sulphur-bearing petroleum from the neighborhood of Lima, Ohio. In 1890 he was transferred to the Standard Oil Co. of Indiana, where he served as chemist. In 1892 he was appointed assistant superintendent of the works, serving in this capacity until 1895, when he was made general superintendent. In 1911 he was elected director, in 1915 vice-president, and in 1918 president, which latter position he still holds.

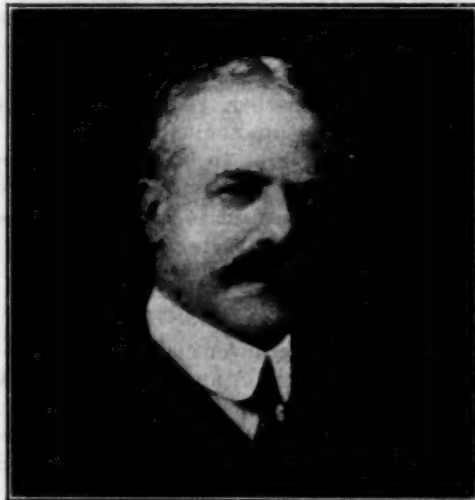
My acquaintance with Dr. Burton began in November, 1895. At that time there was a rumor in Germany that the Standard Oil Co. reserved the pure Pennsylvania oil for the American market and sent the foul-smelling, sulphur-bearing oil from Ohio, Illinois and Indiana to Germany. It was further rumored that the German Government was contemplating forbidding the importation of this oil.

It was quite true that this Ohio oil contained from  $\frac{1}{2}$  to 1 per cent of sulphur, and that when it was fractionated in the usual way, the fractions all carried portions of this sulphur and were offensive and unsuitable for the customary purposes. This was also true of the Canadian petroleum. But Herman Frash began the search for practical methods of removing this sulphur in 1885, at his Empire Company refinery at London, Ont., applying for his first patent in 1887, and by the end of 1894 had applied for twenty patents in this connection. His oxide of copper treatment applied to the usual fractions was a complete success and came promptly into use. So that the Ohio oil was in every

way fully equal in purity and value to the Pennsylvania oil.

Fearing that the German Government might adopt some adverse legislation which it might be difficult to get repealed, the Standard Oil Co. requested me to go to Berlin and convince the government that there was no objection whatever to Ohio oil. In order to be thoroughly informed, I visited and carefully inspected several of the refineries of the company—namely, Olean, Lima and Philadelphia. I found Dr. Burton in charge of the Lima works, and spent a day with him. He interested me so much that I proposed that he should go with me to Berlin, to confer with the government officers.

Late in November we sailed for England and made our way to Bremen, where we consulted with the German representatives of the Standard Oil Co. We then went to Berlin and consulted with representatives of the company there. Our interview with Count Posadowski, the Imperial Minister of the Interior, was entirely satisfactory. He willingly accepted the evidence we presented and all danger of adverse legislation disappeared. For the purpose of strengthening our position we then visited the Imperial Health Department, and the two petroleum experts, Professor Engler in



WILLIAM MERIAM BURTON

Carlsruhe and Professor Louge in Zurich. We had no difficulty in satisfying all these authorities that Ohio oil was in no way inferior to Pennsylvania oil.

Thus I had the pleasure of associating with Dr. Burton on the most intimate terms for nearly 2 months and we became the best of friends. Ever since he became connected with the Standard Oil Co. in 1889 he has devoted his attention to the improvement of methods and means for converting the crude oil into the most valuable products, in the most economical manner, but his methods have rarely appeared in print.

### HIS GREAT INVENTION

Dr. Burton's great invention, which ranks with the manufacture of oil from coal, the boring into the earth for oil by Colonel Drake, the elimination of sulphur from the Canadian and Ohio oils by Frash, was his process for distilling the heavy, high-boiling fuel and gas oil fraction and lubricating oils under high pressure, at a high temperature, in order to convert them into light, low-boiling gasoline.

In the earlier years the production of light oils, gasoline, naphtha, etc., in the fractioning of crude petro-

leum, exceeded the demand. Fifty years ago the wholesale price of refined burning oil was 25c. per gal., while the light oil, under the name of naphtha, was offered at 5c. a gal. Unscrupulous retailers bought both, and mixing them, facilitated "kerosene accidents." The last year before this condition of the oil trade was made public through the New York City Board of Health, there were fifty-two deaths, chiefly of women and children, in New York City caused by kerosene accidents. But with the introduction of the internal combustion engine and the appearance of automobiles, motor cars, trucks, etc., the demand for gasoline has far outstripped the supply.

Dr. Burton promptly attacked this problem of increasing the supply by converting the heavy, high-boiling oils into gasoline, by distilling them under great pressure at a very high temperature. It really seemed an impossible problem on account of the dangers of explosion. But Dr. Burton triumphed, and at the present time very large quantities of gasoline are supplied by this process, and the quantity may be largely increased as the process is more extensively adopted.

I have not gone into details with regard to the process, because I am to be followed by the inventor himself. Incidentally I may add that a valuable variety of asphalt is produced as a byproduct from the cracking of the distillates of the crude petroleum, used in Burton's process of cracking into gasoline.

Dr. Burton received the Willard Gibbs Medal,<sup>1</sup> May 17, 1918, at the meeting of the Chicago Section of the American Chemical Society, in recognition of his distinguished work in petroleum chemistry.

The following articles were published by Dr. Burton, in the *American Chemical Journal*, vol. 11, 1889:

"On the Crystal Form of Metallic Zinc," by George H. Williams and William M. Burton, page 219.

"On the Action of Dilute Acids on Benzoic Sulphinide and the Analysis of Commercial Saccharin," by Ira Remsen and William M. Burton, page 403.

"A Rapid Method for the Estimation of Sulphur in Organic Compounds," by William M. Burton, page 472.

In the *American Chemical Journal*, vol. 12, 1890, were published:

"A Method for the Detection and Estimation of Petroleum in Oil of Turpentine, by William M. Burton, page 102.

"The Atomic Weight of Magnesium, as Determined by the Composition of Its Oxide," by William M. Burton and L. D. Vorce, page 219.

#### U. S. PATENTS ISSUED TO DR. BURTON

Date of Application	Date of Issue	Number	Title
1904, Aug. 12	1904, Oct. 11	772,129	Process of making hydroxy stearic acid
1912, July 3	1913, Jan. 7	1,049,667	Manufacture of gasoline
1912, Sept. 23	1913, Mar. 11	1,055,707	Process of producing asphalt
1913, Aug. 25	1914, Aug. 4	1,105,961	Manufacture of gasoline
1914, Jan. 21	1914, Sept. 29	1,112,113	Process for producing wax from other hydrocarbons
1915, Jan. 23	1915, Nov. 16	1,160,689	Method of safeguarding stills
1915, Feb. 20	1916, Jan. 11	1,167,384	Petroleum products
1916, Nov. 28*	1920, June 15	1,343,674	Distillation of petroleum oils

\* Humphreys and Burton.

#### CONFERRING THE MEDAL

William Meriam Burton, Bachelor of Arts and Doctor of Philosophy: It gives me the greatest pleasure, as the representative of the Affiliated Chemical and Electrochemical Societies of America, to place in your hands this beautiful Perkin Medal, as a token of the appreciation and affection of your fellow chemists.

<sup>1</sup>See MET. & CHEM. ENG., vol. 18, No. 12, p. 647, June 15, 1918.

#### Address of Acceptance

BY WILLIAM M. BURTON

The notification from your secretary, Dr. Rogers, that I had been appointed as a recipient of the Perkin Medal came to me as a most unexpected but happy surprise. The awarding of the Willard Gibbs Medal to me in 1918 would seem to be sufficient recognition, on the part of American chemists, of the industrial work that has been done under my direction; and now comes this additional honor and distinction. I appreciate in the highest degree the compliment this medal conveys, and I hasten to express my most sincere thanks to the members of the awarding committee and to the societies they represent.

The work done under my direction which has perhaps attracted the most attention was carried on principally in the laboratory and refinery of the Standard Oil Co. at Whiting, Ind., a suburb of Chicago, and consisted in devising ways and means for the practical conversion of high-boiling fractions of petroleum into low-boiling fractions in such a way as to insure substantial yields of suitable products with a minimum loss and at a reasonable expense.

#### THE PROBLEM OF MOTOR FUEL

The problem became imperative with the advent of the internal combustion engine about 15 years ago. The most commonly known example of such an engine is, of course, the automobile motor, which, as constructed today, requires a fuel that evaporates at comparatively low temperature, has a high heat value expressed in British thermal units, burns without leaving objectionable residues, does not possess an objectionable odor, is low priced and can be produced in large quantities. Benzene, toluene and alcohol are fairly well suited for the purpose, but their cost and their small volume of production render them largely unavailable.

The low-boiling fractions of petroleum naturally come into use for this purpose, and up to about 1910 the supply of this fuel was sufficient to meet the demand. In fact, the automobile provided an outlet for the sale of these products, which to some extent had been a drug on the market in the oil world. The older refiners in the country will remember when these so-called naphtha products were thrown away and permitted to run down the streams adjacent to the refineries, thereby causing a willful waste and a fire menace to the neighborhood.

Prior to 1910 the average yield of naphtha or gasoline products from crude oil in the United States was about 11 per cent. This yield represented only the amount of such products (of the quality desired at that time) normally present in the crude petroleum and capable of being separated by ordinary methods of distillation at atmospheric pressure. Furthermore, this small yield was sufficient to furnish all that was needed for gasoline stoves and other industrial purposes prior to the use of the internal combustion engine for transportation purposes.

When the automobile came into general use, however, it was perfectly clear that the normal yield of naphtha products suitable for fuel in self-propelled vehicles would not be nearly enough. At that time our refineries were selling about 40 per cent of the products of crude oil for use as fuel and for gas-making purposes in lieu of coal. The remaining 60 per cent represented the normal yield of naphtha and gasoline, illuminating and lubricating oils.

The above-mentioned 40 per cent fuel and gas oil comprised fractions boiling between 225 and 375 deg. C. These oils could, if necessary, be withdrawn from the market, and our problem was to convert them so far as possible into fractions boiling between 40 and 200 deg. C., the product to be equal in quality to normal naphtha products and the yield and operating expense to be commercially feasible.

Our first experiments were directed toward making a suitable product by superheating the high-boiling vapors as such, but without pressure, somewhat along the practice observed in making pintsch gas. We soon found, however, that this so-called "cracking" in the vapor phase required a temperature so high that the aliphatic hydrocarbons contained in the petroleum were largely converted into cyclic and aromatic bodies and fixed gases—unsuited for our purpose. The yield was poor and the quality most undesirable. Obviously our problem included the proposition of reducing the molecular weight without changing the general structure.

We next tried the use of various reagents and catalysts, such as aluminum chloride and ferric oxide. Anhydrous aluminum chloride, indeed, produced some rather remarkable results. The yield and quality of naphtha products were fairly satisfactory, but there was a substantial loss of oil in the operations and the first cost of the anhydrous aluminum chloride, as well as the difficulty in recovering it from the residues, rendered this plan unattractive.

Nearly 30 years ago Sir Boverton Redwood and Professor Dewar in England had patented a pressure-distilling process for the purpose of increasing the yield of kerosene oil from the residues of Russian crude petroleum, but it never was applied industrially. It had been known, therefore, for some years that distilling petroleum under pressure served to break down the high-boiling fractions into low-boiling fractions but, as far as we could learn, no one had ever done it on a large scale and, in fact, such a proposition could not commend itself to a practical refiner because of the obvious dangers from explosions and fires that would be present in handling large stills under such conditions.

#### EXPERIMENTS WITH 100-GAL. STILL

But having tried everything else that suggested itself, we attacked the problem of distilling petroleum in considerable quantities (8,000 to 12,000 gal.) under pressure of about five atmospheres. The first still we built was of a welded design and was planned to handle 100 gal. of the high-boiling fractions. Obviously, the raw material first to be tried consisted of the so-called fuel oil, or reduced crude, meaning the residue of crude oil after the more valuable products had been removed. We soon found that we could not work profitably with this product; when distilled with or without pressure it produced quantities of coke that deposited on the bottom of the still and caused a red hot bottom that would not stand any rise in pressure. The next proposition comprised the use of high-boiling distillates from the crude—viz., oils boiling from 225 deg. C. upward. By using these oils as raw materials we obtained our first encouraging results. We distilled these distillates at a pressure of about five atmospheres and were thereby able to hold down the temperature to a moderate figure, the cracking being done in the so-called liquid phase. By doing the work in this way we found to our intense gratification that the low-boiling fractions produced belonged mostly to the aliphatic or paraffine series, which

were easily deodorized and finished into products suitable for sale. Further, the yield of salable liquid was good and the production of fixed gases and coke small.

#### THE FIRST COMMERCIAL PRESSURE STILL

Experimentally, therefore, our work was successful. But the big problem remained to be solved. Could we build large equipment that would, in a practical way, obtain the desired results and at the same time be durable and reasonably free from the fire hazard that always attends operations in an oil refinery? Some of our practical men said we could, but more of them said we couldn't. In this case, however, the majority was overruled and we immediately prepared plans and specifications for a still 8 ft. in diameter and 20 ft. long, built of  $\frac{1}{2}$ -in. mild steel plates, and holding a charge of 6,000 gal. of raw material. It had a safety factor of 5, the working pressure to be 100 lb., and the bursting pressure 500 lb.

The still was built and charged, with many misgivings on the part of the doubters, but with boldness and confidence exhibited by the rest of us. So soon as we had the still hot and pressure began to develop, we encountered our first difficulty. The still was built in a workmanlike manner and would have made a good steam boiler, but we found rivets and seams leaked badly under oil pressure where they would not under steam pressure. It was difficult to induce boilermakers to calk the leaks while the still was hot and under pressure, but we found men bold enough to do it and the first run was sufficiently encouraging to induce us to proceed further. But the leaks persisted until Nature came to our aid and the minute portions of oil in the leaks gradually carbonized and they closed without our aid.

The experiments with the large still proved our results with the small one—viz., the yield of suitable gasoline fractions was good; the loss was trifling; the cost was reasonable, and the fire hazard under close caution and supervision was not excessive. In addition, we were astonished to find that the residue remaining in the still contained substantial quantities of asphaltine actually created (from a distillate containing none of it) by distillation under pressure.

#### MINOR DIFFICULTIES TO BE OVERCOME

We learned early in the work that operating at moderate pressure required a substantial dephlegmating system that would return to the still the fractions boiling too high for our purpose, and permit the others to pass on. A suitable safety valve that would operate properly with oil vapors at high temperature had to be devised. It would require much more time than I have at my disposal this evening to give a full account of the many difficulties that arose. We had solved the big points, but there were many smaller ones. For successful results we must operate with the oil at temperatures from 370 to 400 deg. C. in the still. At 450 deg. C. steel begins to lose its tensile strength and its capacity to withstand pressure. It is clear, therefore, that with this narrow margin great caution must be exercised to prevent overheating. The human element enters here, as it does in every feature of pressure-still operation, but we operated over 8 years with hundreds of these stills in daily use, and manufactured millions of barrels of gasoline by this method before we had a fatal accident.

After making a number of runs with our 8 x 20 still, and in view of the fact that the demand for gasoline

was increasing at a rapid rate, we asked for an appropriation of \$1,000,000 to build sixty pressure stills 8 ft. in diameter and 30 ft. long, each charging 8,000 gal. of raw material. It required considerable argument to convince any of our directors that such a revolutionary proposition could possibly be successful, but finally they voted in favor of it, and we went ahead.

#### THE PROBLEMS OF TODAY

From the humble beginning of the 100-gal. still in our experimental laboratory, the Standard Oil Co. of Indiana has in operation today over 800 pressure stills having a gross charging capacity of 8,000,000 gal., and licensees under our patents are operating as many more, giving a daily production of 2,000,000 gal. of gasoline out of the total of about 12,500,000 gal. produced daily in the United States and Canada.

This amount of gasoline makes possible the use of two millions of motor vehicles more than could otherwise have been supplied from a given consumption of crude petroleum, and as a corollary of that proposition and assuming 20 per cent of gasoline as a normal average yield from crude oil, the pressure-still process is conserving for future consumption an amount of crude oil equal to nearly one hundred million barrels per year.

The consumption of gasoline by internal combustion engines during the past decade has increased at a terrific rate. In 1910 the United States consumed approximately 700 million gallons, while for 1920 the Bureau of Mines statistics show a total gasoline production of 4 billion 600 million gallons, of which 850 million were made from natural gas, something over 3 billion gallons made by straight crude oil distillation and 750 million gallons made by the cracking process. Further, statistics show that while the increase in crude oil production during the past decade has been 142 per cent, the increase in gasoline production has been over 700 per cent, and although some of this gasoline has been exported, the larger portion has been consumed by the ever-increasing number of automotive vehicles in this country.

The increase in production of crude oil has not been commensurate with the increased demand for its products, and the pressure-still process filled at least part of the gap. Naturally, one is inclined to speculate on what the future will be regarding an adequate supply of these important commodities. One suggestion would be that some of the large amounts of oil now being used for fuel and gas-making purposes be replaced with coal and substantial portions of the oil used for making gasoline, the coal consumption, in turn, to be replaced in part by the development of hydro-electric power.

The American people are notoriously wasteful in the use of natural resources with which they are so highly endowed. It is hoped the work outlined above will be considered a slight contribution toward the curtailment of such waste.

#### ACKNOWLEDGMENT

It would be obviously unfair and unjust to close this paper without duly acknowledging the work done by my associates in successfully establishing the pressure-still process. Our patent attorneys, represented by Russell Wiles, contributed many useful and practical suggestions, and if it had not been for the invaluable assistance of R. E. Humphreys, E. M. Clark, T. S. Cooke and many others connected with the Standard Oil Co. of Indiana, satisfactory results would never have been obtained.

#### Tungsten in the United States

Conditions affecting the production of tungsten in the Boulder County, Col., district are outlined in a report just issued by the United States Bureau of Mines.

It was not until 1900, after the Caribou and Boulder County silver mines had been operated for 30 years, that the heavy dark mineral found as "float" and known to the miners as "heavy iron," "black iron" and "barren silver" was recognized as an ore of tungsten. There was no development of importance, however, until 1914 when the war-time demand for high-speed tool steel, of which tungsten is usually a component, became so great as to cause feverish activity among the owners of the known Boulder County deposits. In the tungsten mining camps the high prices brought about a boom similar to the booms caused by important gold discoveries. The price of tungsten rose to unheard of heights, \$75 a unit or more being the quotation for nearly 2 months, and at least one lot is known to have been sold for \$105 a unit. Such high prices caused the large users to import tungsten ores from South America, and later China, as these foreign ores could be laid down in this country very cheaply. As a result of these importations the market broke rapidly, and during the later part of 1916, 1917 and nearly all of 1918 the price was fairly steady at about \$25 a unit. The small demand, upon the signing of the armistice, together with the large importations and stocks held by dealers, forced the price down so much that early in 1919 all of the Boulder County producers were forced to suspend operations.

Besides the well-known uses of tungsten for high-speed tool steel and incandescent lamp filaments it has been used for replacing platinum and platinum-iridium alloys for contact points in spark coils, voltage regulators, telegraph instruments and other electrical devices; wrought-tungsten targets for X-ray tubes; finely divided tungsten as catalytic agent in the production of ammonia from nitrogen and hydrogen; permanent magnets made by heating and quenching a steel containing 4 to 5 per cent tungsten and 0.5 to 0.7 per cent carbon; and in gas engine parts, such as valves.

#### Exports of Vanadium From Peru

Consul Claude E. Guyant of Lima reports in the Jan. 2, 1922, issue of *Commerce Reports* that during the calendar year 1920 198,760 sacks of vanadium ore, aggregating in weight 10,534 metric tons, were exported from Peru, all shipped to New York, the value of the ore being 2,474,562 soles, which was equivalent to \$1,237,281 (sole = \$0.50)—i.e., 234.90 soles (\$117.45) per ton.

In the first 6 months of 1921 there have been only four shipments of vanadium ore, aggregating 44,562 sacks with a total weight of 2,362 metric tons, valued also at \$117.45 per ton, despite the fact that Peruvian exchange has been more than 20 per cent below par during the year.

The local office of the corporation that has been the principal exporter of this ore advises that the maximum vanadio-acid content of the Peruvian product during the past 2 years has been 26 per cent, the average being 20 per cent.

<sup>1</sup>The development of milling practice in Boulder County, the ore-dressing methods in use and the local manufacture of ferro-tungsten and tungstic oxide are described in Bulletin 187, "Treatment of the Tungsten Ores of Boulder County, Colorado," by J. P. Bonardi and J. C. Williams, which may be obtained on application to the Director of the Bureau of Mines, Washington, D. C.

## What Are the Universities and Technical Schools Doing to Train Their Undergraduates in Industrial Relations?\*

The Engineering School Curriculum Should Contain Courses in the Principles of Industrial Organization, Cost Finding, Wage System and the General Economics of Industry — Study of Human Relations Important—Student Should Be Prepared to Build a Better Industrial World

BY DEXTER S. KIMBALL

Dean, College of Engineering, Cornell University, Ithaca, N. Y.

THE question, "What are the universities and technical schools doing to train their undergraduates in industrial relations?" is very closely tied up with the question, "What *can* universities and technical schools do along these lines?" and a consideration of the latter question is in a measure an answer to the former. Both questions involve a consideration of the basic function of such institutions.

One of the most important developments of recent years is the popular recognition of the efficiency of engineering methods. A few years ago the word "engineering" was used almost exclusively to denote activities connected with the design, construction and operation of machinery, the construction of highways and bridges and similar undertakings. Today we hear of "Industrial Engineering," "Efficiency Engineering," "Financial Engineering," "Human Engineering," and others of similar portent. At first sight some of these terms may seem unwarranted, but they have been coined for lack of better nomenclature. They simply indicate the gradual passing of the old empirical and speculative methods of attacking the problems of industry and the steady growth of the more scientific methods that have become identified with the work of the engineer and scientist.

### EXISTENCE OF ENGINEERING TYPE OF MIND MUST BE RECOGNIZED

Not less important is the recognition of the existence of the engineering type of mind just as we have long recognized the legal type of mind. Natural talents differ, one man being well suited for the study of law and another for the study of engineering or some other calling. The engineering mind is the result of a fairly definite training of an intellect fitted for such work, and the same is true of law or medicine. And it should be carefully noted that this training is fairly well defined in both quantity and content. If this were not so, it would be possible to develop lawyers on some other basis than is now employed and doctors could no doubt be trained without studying medicine. Any course of technical study, therefore, that involves a marked weakening of the fundamentals of engineering education cannot be expected to produce men with engineering minds, and this should be kept constantly in view in discussing the possibilities of the engineer in any portion of the industrial field.

Now the engineer has found an ever-increasing field of usefulness in recent years. Viewed originally as a technical adviser of industry, he has been gradually

drawn over into the administrative field, from the very necessities of the case. As industry has become more technical and more complex it has been found imperative to employ technically trained men to supervise industry of many kinds. And the technically trained man, bringing his own peculiar methods to bear on problems of administration, has already made an assured place for himself as an executive. There can be little doubt that the near future will see the engineer a dominant figure in the administrative side of industry. This must necessarily be so in a civilization such as ours, which depends so largely upon engineering for its existence. As a result of these extended activities, there has grown an increasing demand from practicing engineers and employers that engineering students be given some instruction in economics and such allied studies as refer to the problems of management. And hence practically all good engineering schools in this country include in their curriculum more or less instruction along these lines.

### STUDY OF THE HUMAN FACTOR IN INDUSTRY

But this closer contact with the administrative side of industry has brought the engineer face to face with the greatest problem of all ages—namely, the status of the human factor in industry. Whether he wills it or not, he must face this problem and make an effort to solve it. Others have tried with little success and it remains to be seen whether the engineer with his more scientific methods of attacking industrial problems will succeed in solving this most ancient of all industrial problems.

A recognition of this further extension of the engineer's activities has brought an insistent demand that the curriculum of engineering schools be still further modified to include instruction and study in human relations. The demand is logical and deserves very careful consideration on the part of those who are responsible for technical education. As yet no marked modification of this kind has been made except in a few isolated instances.

While the *character* of the modifications desirable in engineering curricula is well defined, the *degree* to which it is permissible to carry these modifications is not so obvious. Every technical school in the land is beset by urgent requests; in some cases amounting to a demand, that the course of instruction be modified to suit some peculiar industry or the opinion of some particular group of people. Financiers and bankers wish to have their particular field more fully represented. The advocates of the many forms of efficiency engineering have their own peculiar modifications, and those interested in uplift work are advocating complete courses in "human engi-

\*Reprinted from the *Proceedings* of the Academy of Political Science, Kent Hall, Columbia University, New York City, vol. 9, No. 4, January, 1922, on "Constructive Experiments in Industrial Co-operation Between Employers and Employees."

neering" (which expression I detest) to replace in a large measure the courses of instruction now in use.

The tendency of the overenthusiastic teacher is to answer these many and conflicting demands by organizing highly specialized courses of instruction that will prepare the student admirably for a definite and narrow portion of the industrial field at the expense of a broad and solid foundation for his life's work. As a consequence there are now appearing in answer to these demands some narrow and highly specialized courses of instruction such as are suggested in the foregoing. We find elaborate shop organizations for teaching the details of scientific management, so called, and several varieties of special courses in administrative engineering; and some courses have already been established in human engineering, whatever that may be.

#### HIGHLY SPECIALIZED COURSES DEMANDED BY THE INDUSTRIAL MANAGER NOT DESIRABLE

Now without doubt there are some places where special courses of the kinds mentioned are justifiable in the higher technical schools just as specialized trade schools are often justifiable in the lower grades of educational activity. But these special courses do not solve the general problem and there are certain grave objections to these highly specialized courses so strongly demanded by the industrial manager. It should not be forgotten that the *primary* reason why the engineer has been found useful in managerial work is his knowledge of the fundamentals of engineering design and construction and the trained mind that he brings to the consideration of problems of management and organization. That is, aside from personal qualifications that are inherent and cannot be acquired, the technical graduate is good material from which to make an executive simply because he is primarily an engineer by training.

The character of engineering fundamentals and the amount of time that should be spent upon each one is fairly well agreed upon by educators and engineers who have given this matter careful thought. And the constant pressure that has been exerted for many years upon the technical colleges by the advocates of special training of many kinds has resulted in reducing these fundamentals to a minimum. This in itself has been a beneficial influence, but it must not be extended too far. It is not claimed, of course, that the content of these fundamentals, or the methods of presenting them are all that is to be desired. There is much more work to be done along these lines than some of us may be aware of. But at the most these fundamentals can only be concentrated and made more presentable; they cannot be eliminated as some would have us do and still prepare men who will possess the engineering mind. In engineering colleges that require the equivalent of a high school training at entrance it takes about three years to teach the average student the fundamentals of engineering, leaving one year in which to give him some practical applications of these fundamentals in some particular portion of engineering practice. This year of application is not necessarily the senior year, but may be spread out over one or more of the last years of college life. This amount of academic time is also available, therefore, for special instruction in economic and humanistic studies for those who wish to pursue an administrative career.

There is of course the alternative so often and so naturally advocated of lengthening the college course to five or even six years as has been done to some extent

in law and other courses. A discussion of this solution is beyond the limitations of this article. This solution has been tried in several places but so far as the writer is aware there is little reason to believe that such a lengthening of the course will become universal in the near future, and there is no reason to believe that the arguments that resulted in lengthening the course in law are fully applicable to engineering. This discussion will be confined therefore to standard four-year courses which normally send the graduate into the practical field at about twenty-three or twenty-four years of age. In general, the writer believes that this is about as late in life as a young man should begin actual service in the industrial field.

#### EDUCATIONAL CONTENT OF A FOUR-YEAR COURSE

The particular problem under discussion reduces itself, therefore, to the selection of an educational content that can be incorporated into the ordinary four-year course of instruction that will give all students in the college some instruction in the fundamental principles of organization and management, some instruction in basic economic theory and as much instruction as possible in subjects dealing with human relations in industry. This content, so far as industrial organization and economic theory are concerned, is not difficult to find. Thus all engineers should receive instruction in the elementary principles of industrial organization, cost finding, etc., wage system, time and motion study and the general economics of industry. If possible, these subjects should be given before the senior year so that in the senior year the student who so desires may specialize as far along the lines of industrial organization as other students can in such lines of study as gas-engine and steam-engine design, electrical engineering, etc. Space forbids a more detailed statement of such a plan, but actual experience has already shown that such a course will give the student a sound engineering foundation and a good grasp on the fundamentals of economics and industrial organization and management. It will not develop specialists in this or any other line of work nor will it necessarily develop the peculiar personal qualities so often demanded by industrial managers who have peculiar managerial problems to solve.

#### CONTENT OF A COURSE IN HUMAN RELATIONS IN INDUSTRY DIFFICULT TO DEFINE

The educational content of a course in human relations in industry is not so easy to define despite the very large amount of literature that has appeared on this subject. Of course a considerable discussion of human relations in industry is necessarily involved in any discussion of industrial management. But the entire subject of human relations is controversial, to say the least, at present, and the teacher can find little in the industrial field itself that will aid him in drawing accurate conclusions. Certainly the average industrial manager can throw little light upon the most important matter if the results one sees in the industrial field are any indication. Of course there is a considerable literature of the "uplift" kind and there have been many experiments along the line of welfare work, so called, which, because of their failures or successes, indicate that certain efforts may be desirable or undesirable. But a sound philosophy of what human relations in industry should be has not as yet been formulated—at least none that goes beyond a general advocacy of the Golden Rule. Perhaps all that the teacher can do is to call the attention of the student

to this field and direct his thoughts to this, the greatest of all problems. This in itself is something, as it should stimulate the thoughts of these future industrial managers to think of these matters at an early age and long before the age at which most men begin to appreciate this problem. And most certainly everything possible should be done to keep the human element in industry before him and thus offset as far as possible the somewhat detached and materialistic attitude of mind that is so often found in those who concentrate their attention on pure and applied science.

It is not asserted that a training such as is outlined in the foregoing is essential for all industrial managers. We are discussing only the training of high-grade technical men who may be expected to become industrial leaders in a large way. There can be no doubt that many of the proposed courses of training that contain little or no science and engineering will be found of great value in training certain types of men. Schools of commerce have long been successful in training men for business with very little science, pure or applied, in their curriculum; and such courses modified by the introduction of a limited amount of pure and applied science should be of great value to a large number of prospective industrial workers. But such courses do not produce the engineering type of mind. They are not courses in engineering at all, but are often attempts to produce this type of mind by using other educational content and at the same time giving considerable attention to the practical aspects of industrial organization and management. If this can be done, then, as previously stated, lawyers can be trained without studying much law. And those who now so strongly advocate modifications in the engineering courses and the substitutions of large amounts of instruction in industrial relations would be the first to discover that the product of such curricula was not what they had expected.

#### CLOSER CO-OPERATION NEEDED ON THE PART OF INDUSTRY

And the industrial manager must learn that he has duties to perform which up to the present he has shirked or performed but poorly. For after the college has done all it can do for the prospective industrial worker he still is merely good material from which the industrial manager may, if he will, mold an efficient and intelligent industrial leader. The average industrial manager expects to receive from the college a full-fledged engineer or manager, while at the same time he would not think of permitting a newly-graduated doctor to remove his appendix. The technical schools should and can teach fundamentals, but the burden of adapting and specializing the graduate to fit any particular industry should rest squarely upon the shoulders of the industrial manager and of the industry where it rightly belongs. It should be said in all fairness that many progressive industrial managers have already recognized the truth of this statement as is shown by the special provisions now made by industrial concerns to adapt the college graduate to suit their specific needs. Closer co-operation is much needed along these lines.

Furthermore, these considerations are not the only ones to which the colleges must give heed. The primary object of the technical schools was to send out men who would be *useful to the industries*. Most of the technical colleges have not got far beyond this strictly utilitarian viewpoint and the demands of industry tend to keep this viewpoint constantly before them. Our national ideals,

however, have changed greatly since technical colleges were first organized. A new industrial day has dawned in which profits, as such, are not the most important consideration, and industry is coming to be looked upon as a means of supporting human existence, not as a means of corporate profit. We have become more interested in men than in machines.

#### THE KIND OF INDUSTRIAL EFFICIENCY TO BE DEVELOPED

Industrial efficiency we must develop, but the fruits of this efficiency must be for all if we adhere to our present national ideals of democracy. An efficiency that benefits the employer and not the employees, or an efficiency that builds up the state at the expense of the individual, is foreign to these ideals. If technical graduates are to take an active part in industrial management, and it seems assured that they will, the colleges will be remiss in their duty if they do not include in their course of instruction such work as will give their students some idea of the modern views of the distribution of the fruits of industry. Here is an educational problem and an educational content to be formulated regarding which little is said in the criticism of the technical graduate, though it is one of the most important of educational problems. "Where there is no vision the people perish," said the prophet of old, and this is as true today as it was thousands of years ago. Efficient industrial managers we must have; but if the republic is to endure we also must have industrial managers whose vision will be great enough to look beyond the petty requirements often laid upon the technical school for the man who, *while useful to his industry*, can also do something to make industry *more useful to all men*.

For after all, ideals and not technical developments move the world. The recent remark of a great industrial leader that if he had his way he would put business men at the headships of our colleges and universities shows a lamentable lack of knowledge of the principal purpose of such institutions. Technical and commercial efficiency we must have, and the problems of production must be solved. But it will avail us nothing if we cannot also solve the problem of human relations. Our business men and financiers cannot lay claim to much progress in solving this last problem. Yet it is the one great problem and one that requires not only industrial knowledge but high idealism and a love for humanity. It has been charged that the colleges and universities are too far removed from industry and the practical things of life. This may or may not be true, but it is sincerely to be hoped that there will always be in this land great institutions of learning that are not dominated solely by industry or industrial ideas, where great teachers will have an opportunity to prepare men not only for the industrial world that now exists, but will also be free to prepare them to build a better industrial world to come.

#### Michigan Leads U. S. in Paper Mill Growth

Michigan has led all other states of the Union in the growth of the paper industry during the past 5 years, as in this time 27 new mills have been constructed and placed in operation, increasing the number from 39 to 56. There are now 105 paper machines in service, as compared with 89 machines installed in 1917. Kalamazoo and Monroe are the centers of the industry in the state. Kalamazoo leads the country in the manufacture of book papers. Monroe leads in boxboard.

# Brittleness Developed in Pure Lead by Stress and Corrosion

It Has Been Known That Corrosion Induces Intercrystalline Brittleness—It Is Now Shown That Damage Is Accelerated by Accompanying Stress—A Method Is Noted of Making Large Columnar Crystals or Stalactites of Metal

By HENRY S. RAWDON, ALEXANDER I. KRYNITSKY AND JULIUS F. T. BERLINER\*

IN A previous publication<sup>1</sup> it has been shown that the condition of intercrystalline brittleness sometimes found in lead by which the metal may be changed to the form of a granular powder is the result of selective corrosion of certain portions of the material rather than to an allotropic change, as had been previously stated by some investigators. The results obtained by Thiel<sup>2</sup> confirm those given in the publication referred to above. It was shown further that the readiness with which such intercrystalline brittleness may develop is a function of the purity of the metal and that by a selective corrosive attack of impurities existing as intercrystalline lodgments the change is brought about. By the use of suitable corrosive agents, even very high-grade lead can be made to exhibit intercrystalline brittleness to an appreciable extent.

## SIMULTANEOUS ACTION OF TENSILE STRESS AND CORROSION

Lead, as cable sheathing and in other similar forms, is sometimes subjected to considerable tensile stress during its service. For this reason a series of experiments to demonstrate the influence of externally applied stress upon embrittlement seemed very desirable.

The material from which the specimens were prepared was of very high purity<sup>3</sup> (99.99 per cent) in order to minimize any effect caused by impurities in the material. It was cold-rolled into rods of  $\frac{3}{8}$  in. diameter and then drawn to a 0.164-in. diameter wire. Specimens approximately 10 in. long were cut from the wire and annealed for 2 hours in an oil bath at 216 deg. C.

In the determination of the mechanical properties of lead, the results are influenced in a very marked degree by the conditions under which such properties are determined, particularly by the rate at which the load is applied. The ultimate tensile strength of the material to be used was determined by a "dead weight" loading by the addition of small weights, approximately 4 oz. each, to a container suspended at the free end of a specimen held in a clamp. A period of approximately 10 minutes was required for the addition of sufficient load to break a specimen. The material was found to have an ultimate strength (as determined under these conditions) of 1,705 lb. per sq.in.

The appearance of the fractured ends of a lead wire broken in this way is shown in Fig. 1. In this case, however, the specimen was loaded with a weight of only 710 lb. per sq.in. and a period of 12 days was re-

quired to cause fracture. In addition to the sharp "necking-down," a characteristic roughening of the surface for some distance back of the break occurred. The specimen also showed a trace of what appeared to be intercrystalline fissures,<sup>4</sup> in the roughened portion.

For demonstrating the effect of the simultaneous action of tensile stress and corrosion, a cylindrical glass container was fitted around the central portion of each specimen. The solutions used and the applied loads are summarized in Table I. In each case the corroding solution surrounded the lead specimen for a distance of approximately 1 in., and the surface of the liquid was covered with a thin layer of sperm-oil to prevent excessive evaporation and also to minimize the accelerating effect of atmospheric oxidation. The loads applied to the specimens were arbitrarily chosen, one-tenth, one-fourth and one-third of the ultimate strength in tension, as previously determined, being used. The



FIG. 1. PURE LEAD BROKEN AFTER HOLDING 710 LB. PER SQ.IN. FOR 12 DAYS.  $\times 3$

attempt was made to employ a maximum load of one-half the ultimate tensile strength of the material, but it was found impossible to use such a load on account of the flowing of the metal and subsequent breaking in the grips.

From the results summarized in Table I it will be seen that many of the specimens which were surrounded by the mildly corroding liquids failed from various causes before the completion of the test. In some cases fracture occurred in the grips on account of the gradual flowing of the metal at these points under a larger stress at these portions caused by the flattening of the material. The ability of lead to flow gradually under the continued application of a load which may be very much less than the "tensile strength" of the material is very characteristic and also well known.

In most of the specimens for which the test period was rather long, considerable localized corrosion occurred just above the oil layer. On account of the disturbance of the rack on which all the weighted specimens were hung, by reason of the breaking of specimens at different intervals and from accidental

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\*Physicist, Associate Physicist and Laboratory Assistant, respectively, Bureau of Standards.

<sup>1</sup>H. S. Rawdon, "Intercrystalline Brittleness of Lead," Bureau of Standards Sci. Papers 377.

<sup>2</sup>A. Thiel, "The Apparent Allotropy of Lead," *Ber.*, vol. 53B, pp. 1052-66 (1920). Also *Chem. Abs.*, vol. 14, p. 3006.

<sup>3</sup>The material used was the high-grade lead described in Sci. Paper 377.

<sup>4</sup>W. Rosenhain and S. L. Archbutt, "Intercrystalline Fracture of Metals Under Prolonged Application of Stress," *Proc. Roy. Soc. London*, vol. A96 (1919), p. 56.

TABLE I. EFFECT OF THE SIMULTANEOUS ACTION OF TENSILE STRESS AND CORROSION UPON LEAD

Specimen No.	Liquid Surrounding Stressed Specimen	Load Applied to Specimen 0.164 In. Diameter, Lb.	Unit Stress Computed, Lb. per Sq. In.	Time Interval Before Fracture Occurred, Days	Remarks
1	Distilled water.....	3.6	170	...	Specimen intact; no evidence of embrittlement after 340 days.
2	Distilled water.....	9.0	426	...	Broke in upper grip after approximately 200 days.
3	Distilled water.....	12.0	568	...	Broke in 83 days—just above oil layer, no evidence of embrittlement.
4	N <sub>2</sub> aqueous lead acetate solution.....	3.6	170	...	Specimen intact; no evidence of embrittlement after 340 days.
5	N <sub>2</sub> aqueous lead acetate solution.....	9.0	426	...	Broke in 202 days, just above the layer of oil.
6	N <sub>2</sub> aqueous lead acetate solution.....	12.0	568	...	Broke early in the test period, record lost. No embrittlement.
7	N aqueous lead acetate.....	3.6	170	...	Specimen intact after 340 days. embrittlement started, intercrystalline fissures have formed.
8	N aqueous lead acetate.....	9.0	426	...	Broke in 192 days, just above the lower grip.
9	N aqueous lead acetate.....	12.0	568	117	...
10	N <sub>2</sub> aqueous lead acetate solution + N <sub>2</sub> nitric acid.....	3.6	170	94	Fig. 4.
11	N <sub>2</sub> aqueous lead acetate solution + N <sub>2</sub> nitric acid.....	9.0	426	21	Figs. 2 and 3.
12	N <sub>2</sub> aqueous lead acetate solution + N <sub>2</sub> nitric acid.....	12.0	568	15	Fig. 5.
13	N aqueous lead acetate solution + N nitric acid.....	3.6	170	13	Fig. 6.
14	N aqueous lead acetate solution + N nitric acid.....	9.0	426	9	Fig. 7.
15	N aqueous lead acetate solution + N nitric acid.....	12.0	568	5	Fig. 8.

jarring of the liquid in the cups surrounding the lead samples, some of the specimens became covered with a slightly emulsified layer of lead acetate for a short distance above the surface of the oil layer. The difference in the rate of corrosion along the bar was great enough in two cases as to cause the specimen to fail in the upper part before the portion surrounded by the corroding liquid was appreciably attacked.

The results obtained (Table I) plainly indicate that embrittlement of lead quickly results when the metal is submitted to the simultaneous action of tensile stress and corrosion. Figs. 2 to 8 show the characteristic appearance of specimens after the attack. The fact that the fissures which form are intercrystalline was readily revealed by microscopical examination of longitudinal sections of broken specimens.

In general, the results of the tests indicate that while the application of a tensile stress powerfully accelerates embrittlement of lead, corrosion is of more fundamental importance in causing the embrittlement

to occur. The regularity in the rate at which failure occurred with respect to the concentration of the corroding solution and also to the magnitude of the applied stress suggests very strongly that after a sufficiently long interval of time the specimens subjected to the action of the very mildly corroding solutions would

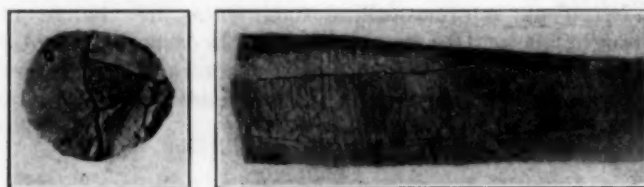


FIG. 9. COARSE-GRAINED LEAD AFTER 42 DAYS IN 2N NITRIC ACID PLUS N LEAD ACETATE. NATURAL SIZE

behave in a similar manner if other conditions do not interfere. However, whether lead is sufficiently soluble in distilled water to permit failure by "intercrystalline brittleness" to occur is not apparent and can only be conjectured.

It is not to be concluded that embrittlement of lead always necessitates a corrosive attack of the metal. It has been known for some time by users of lead cables that overhead cables on bridges and similar structures which are subject to vibration must be supported in a special way so as to minimize the vibratory effect on the cable, otherwise embrittlement cracks will develop as a result of the stress conditions. Such cases have recently been described by Archbutt.<sup>4</sup> The intercrystalline character of cracks produced under such conditions, however, is not so evident as when corrosion is one of the factors which bring about their production.

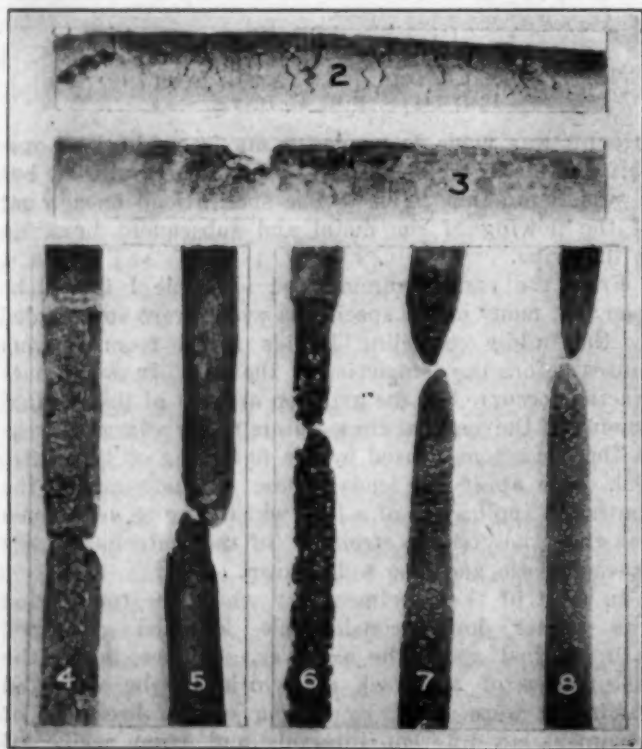
#### CORROSION OF COARSELY GRAINED LEAD

The fact that the corrosive attack of lead is truly intercrystalline is shown in Fig. 9 in a very striking manner by the use of excessively coarsely grained material.<sup>5</sup>

In Fig. 9 is shown a 2-in. section of a lead "stalac-

<sup>4</sup>L. Archbutt, "Failure of Lead Sheathing of Telegraph Cables. Contribution to Symposium on Effect of Prolonged Application of Stress on Metals," *J. Faraday Soc.*, vol. 16, April, 1921.

<sup>5</sup>Some very coarsely crystalline bars in the form of icicles or stalactites were prepared by John R. Freeman, Jr., Associate Physicist, Bureau of Standards, thus: An iron rod was allowed to touch the surface of the molten metal and, after a sufficient amount of lead had solidified upon it, was slowly moved upward at a carefully controlled rate. By properly adjusting the rate at which the rod is moved a bar of lead resembling an icicle in shape may be produced, consisting of a relatively very small number of crystals. In some cases a single crystal may form the entire cross-section of the rod.



FIGS. 2 TO 8. PURE LEAD BROKEN UNDER COMBINED STRESS AND CORROSION, AS NOTED IN TABLE I.  $\times 3$

tite" after corrosion for 43 days in a nitric acid solution. It will be noted that the crystals, as seen on the end of the corroded specimen, are separated from one another by conspicuous "ditches," the width and depth of which can be readily observed without resorting to the use of the microscope. The chemical analysis of lead used indicated the composition to be as follows: Lead, 99.94 per cent; copper, 0.03 per cent; and antimony, 0.03 per cent. The depth and width of the intercrystalline "ditches" which form during corrosion appear to be related closely to the grain size and to be more prominent than might be expected from the small percentage of impurities in the metal. This suggests that, at least in the case of lead, the intercrystalline impurities may not be entirely responsible for the intercrystalline attack during corrosion.

#### SUMMARY

The results obtained in the preceding experiments in connection with those previously described in the publication cited in footnote 1 indicate that lead is quite different from the other soft metals in its behavior upon prolonged corrosion. This metal, even of a very high degree of purity, develops intercrystalline brittleness when subjected to a corroding medium, particularly of an acid nature, for a considerable period of time. The application of an externally applied stress while subjected to the action of a corroding solution is a powerful adjunct in producing intercrystalline brittleness, as was exemplified in the case of lead. Specimens broken in tension under such conditions have an appearance characteristic of a brittle material. Examination readily shows, however, that only the "bond" between adjacent crystals has been affected; the grains themselves retained their ductility and other characteristic properties.

## Sulphuric Acid Tank Leaks Caused by Wood Borers

BY C. E. CRESSE\*

TANKS for holding sulphuric acid at the Chicago Heights plant of the Armour Fertilizer Works were built from North Carolina pine cut in the winter. The bottom of each tank was formed from 2 x 8-in. planks laid flat, and the sides and ends were made up by laying 2 x 8-in., 2 x 6-in., and 2 x 4-in. planks flat with the 2-in. edge next to the inside of the tank, which was lined with sheet lead about  $\frac{1}{2}$  in. thick. Reference to Fig. 6, page 336, CHEMICAL & METALLURGICAL ENGINEERING, vol. 24, 1921, will give a clear idea of this method of construction.

#### HOLES NOT APPARENT TO THE EYE

The tanks were filled with 50 per cent sulphuric acid in May, and when 5 weeks later they began leaking, the acid was drawn off and an investigation made. Considerable difficulty was encountered in locating the trouble because no holes were apparent to the eye on the interior lining. The approximate locations of the leaks were determined by the moist spots in the wood on the outside, the lead was cut and curled back and the work of the wood borer disclosed.

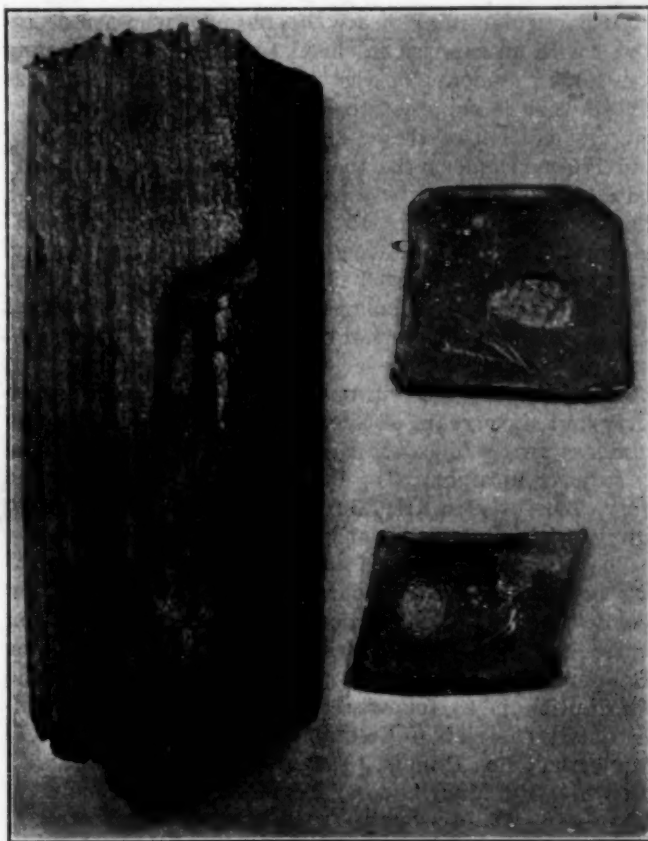
Specimens of the beetle were sent to a Washington government department, where it was identified as the

Capricorn beetle, more commonly known as the Goat beetle or Sawyer worm. This Southern pine sawyer is named more technically the *Monohammus confusor*. Starting as an egg laid by the female beetle on the surface of the timber, he hatches into a borer. He feeds on the sapwood, weaving back and forth until grown to full size, when he mines deep into the heartwood and back to the surface again. Here he passes through a resting stage and is transformed into a long-horned beetle. Many kinds of forest trees are attacked by the borer with serious damage to the timber.

#### TIMBER CONTAINED MANY BORERS

Evidently the timber from which these tanks were made contained a large number of borers. When they mined to the surface and encountered the lead lining of the tank the "goat" instinct was aroused and they proceeded to dine on the lead. All activity, "goat" and otherwise, ceased, however, when they tapped the sulphuric acid.

In the accompanying illustration are shown on the left the progress of the worm through the timber and



PHOTOGRAPH SHOWING PROGRESS OF THE WOOD BORER

On the left is shown the path of the worm through the wood and the exit where it attacked the lead lining. On the right are photographs of the holes made by the borer on the outer side of the lead lining—i.e., next to the wood. The sharp tooth marks are plainly visible.

the exit where it attacked the lead lining. On the right are photographs of the holes made by the borer on the outer side of the lead lining—i.e., next to the wood. The sharp tooth marks are plainly visible.

The action of wood borers causing leaks in acid tanks and chambers has been known for several years, but preventive measures are usually considered too late. It is recommended by the United States Forest Service that such wood be treated with creosote to kill these pests before it is employed for construction purposes.

\*General Superintendent, Armour Fertilizer Works, Chicago Heights, Ill.

## American Chemists—A Statistical Study

BY GERALD L. WENDT  
University of Chicago

THE data given in the edition of "American Men of Science" for 1920 furnish the following facts relative to the distribution and education of the leading American chemists. The chemical profession still leads all others in the number of its representatives listed. Of about 9,500 men listed 1,852, or 19.5 per cent, are chemists, including biological chemists, chemical engineers, industrial chemists, physical chemists, etc. This is about 12 per cent of the 15,000 membership in the American Chemical Society. In point of age and eminence the list is headed by Dr. Charles William Eliot, president emeritus of Harvard University, born on March 20, 1834, who was assistant professor of chemistry at Harvard from 1858 to 1863 and professor of chemistry at the Massachusetts Institute of Technology from 1865 until his election to the presidency of Harvard in 1869.

Of particular interest are the 220 men who are designated with an asterisk in chemistry and are thus among the 1,000 "students of the natural and exact sciences whose work is supposed to be the most important." In the first edition of this compilation, in 1905, chemistry had 175 men among the thousand, or 17.5 per cent, and led all other sciences by a handsome margin. This lead has in the intervening 15 years been increased to 22 per cent. In the following study of these 220 men no individual names are mentioned, since the inclusion or exclusion of any particular name in this list is subject to a large error of personal choice. The statistics based on large numbers, however, are of value.

As would be expected, most of the men are between forty and sixty years of age. Divided into decades, the numbers are as follows: Eighty to ninety years of age, 3; seventy to eighty, 21; sixty to seventy, 37; fifty to sixty, 76; forty to fifty, 59; thirty to forty, 22; below thirty, 1; date of birth not given, 1.

The geographical distribution of these leading chemists shows a great preponderance along the northeastern coast. In the states bordering on the Atlantic from Massachusetts to the District of Columbia are 151, or 68.6 per cent. Listed by states in numerical order the distribution is as follows: New York, 55; Massachusetts, 25; District of Columbia, 21; Pennsylvania, 17; Connecticut, 14; Illinois, 13; California, 12; New Jersey, 10; Ohio, 10; Maryland, 6; Michigan, 5; Wisconsin, 5; Minnesota, 4; Missouri, 4; Kansas, North Carolina, Nebraska, Rhode Island and Virginia, 2 each; Delaware, Indiana, Iowa, Nevada, New Hampshire, South Carolina, Texas, Utah, British Columbia, 1 each. There remain twenty-two states with no leading chemist.

### DOCTOR'S DEGREES HELD BY LEADING CHEMISTS

Of these 220 chemists seventy have honorary degrees, chiefly Sc.D. and LL.D. Of the 70 recipients of honorary degrees 3 have no other degrees whatever, 11 have a bachelor's or master's degree but no Ph.D., and 56 have both a bachelor's or master's degree and the Ph.D.

Only 149 of the 220 leading chemists have the Ph.D. degree, while 71 do not have it. Of the 149 who have the Ph.D. degree 56, or 37.6 per cent, obtained it in Europe. This is a large fraction, but it is rapidly diminishing. Of the 23 men born since 1880, only 3, or 13 per cent, have a European Ph.D., while of the

remaining 126 born in 1880 or before, 53, or 42 per cent, have a European Ph.D. The 56 Ph.D.'s granted by European universities are distributed as follows: Leipzig, 18; Göttingen, 15; Heidelberg, 10; Berlin, 3; Munich, 2; Strassburg, 2; Bern, Breslau, Freiburg, Hanover, Jena, and Zurich, 1 each. The 93 men who received the Ph.D. from American universities are distributed as follows: Johns Hopkins, 22; Harvard, 14; Yale, 13; Chicago, 10; Pennsylvania, 6; Columbia, 4; Massachusetts Institute of Technology, 3; Cornell, Illinois Wesleyan, Michigan, North Carolina, Stanford and Wisconsin, 2 each; Brown, California, George Washington, Illinois, Kansas, Lafayette, Minnesota, Ohio (Athens), Princeton, Toronto and Tufts, 1 each. (Two men have 2 Ph.D.'s each.) Thus 73 of 95 degrees were given by the endowed universities, and only 22 by the state universities. Of the 71 chemists who have no Ph.D. degree, 11 have honorary degrees and 42 have bachelor's or master's degrees, 11 have M.D.'s and 18 have no degree whatever.

The fact that one-third of our leading chemists do not have the Ph.D. degree is perhaps surprising. It should be remembered, however, that the list includes industrial chemists and thus a number of heads of large commercial establishments who have not themselves contributed to the science of chemistry. In addition, a number of names are of executive officers in the Chemical Warfare Service, U. S. Army, whose contributions are not strictly chemical. Finally, it should be noted this condition does not apply to younger men. Of the 141 men fifty years of age or over, 53, or 38.6 per cent, do not have the doctorate degree; but of the 23 men under forty years of age only 5 do not have the degree. Of these, 2 are Englishmen, educated in England, where this degree is not regular. There remain only 3 men, or 13 per cent, who do not have the degree. One of these was a Colonel in the C. W. S., one is an editor and one is a chemical engineer in charge of a large government laboratory.

### DISTRIBUTION OF BACHELOR'S DEGREES

The distribution of bachelor's degrees is also of interest. Among this group of 220 chemists 174 have bachelor's degrees, of whom 11 have two each. The 185 degrees are distributed among the universities as follows: Harvard, 22; Yale, 16; Massachusetts Institute of Technology, 15; Michigan, 9; Wisconsin and Columbia, 6 each; Cornell, Johns Hopkins and Pennsylvania, 5 each; Amherst, California, Ohio State, Toronto and Williams, 4 each; College of the City of New York, Kansas, Princeton and Wesleyan, 3 each; Edinburgh, Haverford, Illinois, Lafayette, Nebraska, New York, Rutgers, Stanford, Tufts and Worcester, 2 each; Beloit, Bethany (Kan.), Bowdoin, Brown, Buechel, Bucknell, Case, Chicago, Cincinnati, Colorado, Dalhousie, Davidson, DePauw, Doane, Earlham, Georgia, Gettysburg, Grinnell, Hamilton, Hanover, Kentucky, Knox, Lehigh, Maine, Middlebury, Minnesota, Muhlenburg, North Carolina, Northwestern, Penn. State, Purdue, Rensselaer, Rhode Island, Swarthmore, Texas, Vanderbilt, Virginia, Washington and Lee, Westminster (Pa.) and Wooster, 1 each.

It is thus apparent that Harvard and Yale stand out both in graduate and in undergraduate work, while Johns Hopkins and Chicago predominate in graduate instruction and Massachusetts Institute of Technology and Michigan show undergraduate strength. Other deductions must be left to individual interest.

# The Distillation of Coke-Oven Tar and the Recovery of Some of Its Products

An Outline of Current Practice in the Refining of Coal Tar and Its Principal Products of Commercial Importance—Description of Processes Involved in Recovery of Tar Acids, Naphthalene, Anthracene, Creosote Oils and Pitch

By WILBERT J. HUFF

THE successful results achieved by the use of coke-oven tar as a fuel in open-hearth steel furnaces have led to its extensive consumption in such furnaces, and since the majority of byproduct coke ovens are operated in connection with steel works, much of the tar is utilized as fuel near its point of origin. Coke-oven tar, however, compares very favorably with coal tar of other origin, and is admirably adapted to profitable distillation. This is, of course, very advantageous where all of the tar is available, as in the case of byproduct ovens operated primarily for the production of gas.

Coke-oven tar, or any coal tar, may be the source of a great many chemical products. However, most of these fall outside the province of the tar distiller, who finds it economical to confine his attention to the following chief products: Creosote oil, naphthalene, anthracene, carbolic and cresylic acids and pitch. Small quantities of light oil, ammonia water and pyridine are also recovered.

In the crude tar, these materials are so thoroughly incorporated with one another that it is necessary to have recourse to a process of fractional distillation and chemical treatment in order to separate them. The following fractions are usually separated:

(1) From atmospheric temperatures to 170 deg. C. (338 deg. F.): Products: Light oil, water, some pyridine,<sup>1</sup> some naphthalene.

(2) From 170 deg. to 235 deg. C. (338 deg. F. to 455 deg. F.): Products: Crude phenol, cresylic acid, naphthalene (crude), pyridine, creosote oil.

(3) From 235 deg. to 270 deg. C. (455 deg. F. to 518 deg. F.): Products: Creosote oil, naphthalene (crude).

(4) From 270 deg. to 315 deg. C. (518 deg. F. to 599 deg. F.): Products: Creosote oil, anthracene (crude).

(5) From 315 deg. to 355 deg. C. *supra* (599 deg. F. to 671 deg. F.): Products: Creosote oil, anthracene (crude).

In fraction 1, the water forms an immiscible layer which is readily separated. It contains some ammonia and its compounds, but the recovery of this is rarely undertaken save when the tar distillation plant is near a byproduct coke plant. The light oil may be pumped to the light-oil still of the coke plant to be rectified together with the light oil from the gas. The naphthalene contained in this fraction is thus taken care of in the regular coke-plant operation where the naphthalene appears in the still residues.

When the remaining condensates cool, they each give

two phases, one an oil, brown or green in color, the other a solid, partially crystalline. The solid from fraction 2 is crude naphthalene. That from fraction 3 is largely crude naphthalene, although a little crude anthracene may appear. The solids in fractions 4 and 5 are called crude anthracene, although they are really a mixture of crude anthracene, carbazol and phenanthrene, together with a large number of less important hydrocarbons. When the solids have completely separated, the oils are drained off and the solids centrifuged or pressed to remove adhering oil. When sufficient distillate has been removed, the hot liquid pitch remaining is discharged directly into steel tanks or bays, where it is allowed to cool for subsequent handling and transportation.

The temperatures given represent vapor temperatures noted during the distillation and, because the character of a fraction cut from such a complex mixture varies with type of apparatus, these temperatures are only approximate. The practical tar distiller determines his cut points by observing changes in the character of his condensate. This should be remembered in reading the following pages.

Following is the distillation record<sup>2</sup> for a typical tar from a byproduct coke oven:

Fraction No.	Temperature, Deg. C.	Gal. per 1,000 Gal. Tar	Per Cent by Volume Referred to the Original Tar Vol.
1	Atmospheric—170	Oil—14.5 Water—15.5	1.45 1.55
2	170-235	122	12.2
3	235-270	123	12.3
4	270-315	133	13.3
5	315-355	98	9.8
Residue and losses		494	49.4

Weight of residue, 57 per cent of original tar.

The following products may be obtained from such tar:

	Gal. per 1,000 Gal. Tar	Per Cent by Volume
Ammonia water.....	14.5 (0.6 lb. NH <sub>3</sub> est.)	1.5
Light oil.....	15 (naphthalene not determined)	2.6
Tar acids.....	26	

	Lb. per 1,000 Gal.	Per Cent by Weight
Crude Naphthalene		
170 deg.—235 deg. C. fraction	200	2.2
235 deg.—270 deg. C. fraction	48	0.6
Total.....	248	2.8

	— Lb. per 1,000 Gal. —		— Per Cent in Weight —	
	Without Chilling	Additional Recovery Due to Chilling	Without Chilling	Additional Recovery Due to Chilling
Crude Anthracene Cake <sup>3</sup>				
270 deg.—315 deg. C.	46.5	9.4	0.47	0.095
315 deg.—355 deg. C.	93.0	9.4	0.95	0.095
Total.....	139.5	18.8	1.42	0.19

<sup>1</sup>In interpreting tar analyses, it should be remembered that it is not possible to attain in tar analyses the high precision of most chemical analyses. Moreover, from time to time the composition of the tar changes somewhat due to variations in the operating conditions and the coal supply.

<sup>2</sup>The exact composition of these tar acids was not determined. The probable composition is crude phenol approximately 1 part, cresylic acid approximately 2 parts.

<sup>3</sup>The exact per cent anthracene was not determined.

<sup>1</sup>The pyridine content is small and in this country its recovery is seldom undertaken.

Pure anthracene ( $C_{14}H_{10}$ ) is a solid hydrocarbon which on oxidation gives anthraquinone, whose dihydroxy derivative is alizarine, an extremely important red dye. Anthracene is rarely obtained pure. Phenanthrene, carbazol, acenaphthene, fluorene, methylanthracene, chrysene, pyrene and a great many other hydrocarbons are intimately associated with it and possess so many properties in common with it that the isolation of pure anthracene is rather difficult. The refined anthracene of commerce contains about 80 per cent of anthracene.

Government statistics<sup>1</sup> for 1920 show a total production of almost three million pounds of crude anthracene (25 per cent) and 100,000 lb. of refined anthracene (on the basis of 100 per cent). This is somewhat less than the requirements of the dye industry caused principally by the fact that there is no great demand for hard pitch in the American market; consequently, much of the anthracene is not distilled out of the pitch.

Carbazol [ $(C_6H_4)_2NH$ ] is found intimately associated with anthracene and although always a constituent of crude anthracene cake, it is not generally isolated by the tar distillers. Dye companies purchasing anthracene sometimes insist on a content of anthracene not too high (maximum about 55 per cent), thus insuring a supply of carbazol as a byproduct of the anthracene purification process. Carbazol is the source of some very important dyestuffs, among which are carbazol blue and carbazol yellow.

Naphthalene ( $C_{10}H_8$ ) is the most familiar pure product of the tar distillery. Its uses are many and constantly increasing. In the field of dyes it serves as a starting point for all the phthalein colors, such as eosine, crythrosin, etc., a great many azo colors containing naphthols. The chemical uses for naphthalene have been stimulated in the past few years by the discovery of a catalytic process whereby naphthalene is oxidized by air to valuable intermediate products, chiefly phthalic acid.<sup>2</sup> The deficiency in the supply of anthracene is being made up in part by synthetic anthraquinone prepared from phthalic acid.

While it is probable that these uses for naphthalene will increase, such an increase will probably not absorb the complete production of naphthalene, and studies are in progress to extend the uses. One of the recent developments is the hydrogenation of naphthalene to compounds such as tetra-hydro-naphthalene and deca-hydro-naphthalene. A mixture of these gives a liquid oil which absorbs oxygen and becomes sticky, and is offered as a turpentine substitute.<sup>3</sup>

The possibility of developing a use for naphthalene such as driving internal-combustion engines is of interest. For this purpose it is of course not necessary to purify the commercial recrystallized material, since this is a nearly pure chemical compound of definite boiling point, practically free from gum- and resin-forming materials. To permit easy handling it is formed into balls and is fused just before it enters the engine.

Naphthalene when mixed with pitch serves to lower

the melting point and decrease the viscosity. Consumers of liquid fuel oil who wish to obtain this oil by distillation of tar to a very soft pitch may carry the distillation to a harder pitch, thus obtaining more liquid oil, and cut back the pitch to a softer grade again by adding to it crude naphthalene.

**Tar Acids.** Coal tar contains an extremely important group of compounds which are acidic in nature—i.e., they are capable of forming water-soluble compounds when treated with caustic. They redden litmus paper, are themselves soluble in water to varying degrees, and possess important antiseptic and germicidal properties. The number of these tar acids is probably large, and they appear to some extent in all the fractions, but are at the highest concentration in what is sometimes called the carbolic fraction (i.e., 170 to 235 deg. C.) and this is the only fraction regularly washed for tar acids. This contains chiefly only phenol and cresols, and these two compounds are the only ones separated by the tar distiller, the higher boiling tar acids being permitted to remain in the creosote oil, where they form important agents for the protection of wood.

Perhaps the greatest demand for phenol will come from the manufacture of the synthetic phenol-formaldehyde resins. These resins, which generally resemble hard rubber, have an enormous variety of uses in the technical and industrial world. A very familiar product containing such resins is the phonograph record. These resins can consume an enormous amount of phenol (or cresol), possibly millions of pounds, provided the phenol can be obtained at a favorable price.

Another use which consumes a large quantity of phenol is the manufacture of disinfectants and germicides. Carbolic acid and carbolated products are too well known to require comment. Prior to the introduction of phenolic resins, the chief commercial outlet for phenol rested upon its antiseptic and germicidal properties.

Pure cresol of commerce is a mixture of three isomeric compounds having the formula  $C_6H_4OHCH_3$ . The tar distiller generally does not endeavor to isolate any one of the cresols pure. However, ortho-cresol may be separated from phenol and the other cresols by fractionation through a good column, and for that reason can be purchased pure. Neither meta- nor para-cresol is regularly offered for sale in its pure form, since it is impossible to separate these by fractionation. Instead a mixture, known as meta-para-cresol, is offered.

The cresols are more efficient bactericides than phenol, and at the same time are less poisonous, consequently they are preferred for many uses. The important formaldehyde condensation products known as the synthetic phenolic resins can be prepared from the cresols as well as phenol. The cresols play an important part in the manufacture of certain coal-tar colors and are often prepared pure by the dye manufacturer.

**Tar Bases.** In contrast with the acidic compounds found in coal tar there exists a group of basic compounds, containing nitrogen, of which the most important are pyridine and its derivatives. These are extracted from certain of the tar oil fractions by washing with dilute sulphuric acid.

Pyridine, however, is rarely isolated pure. Commercial grades generally contain a little water and higher boiling bases. The more volatile fraction of commercial pyridine (115 to 160 deg. C.) is used in denaturing alcohol because of the nauseating taste and

<sup>1</sup>Census of Dyes and Coal-Tar Chemicals, 1920. U. S. Tariff Commission. (See CHEM. & MET. ENG., vol. 25, No. 4, p. 166, July 27, 1921.)

<sup>2</sup>H. D. Gibbs and C. Conover, U. S. Patent 1,284,888, Nov. 12, 1918. This patent was developed in the Color Laboratory of the U. S. Bureau of Chemistry, and is dedicated to the people of the United States.

<sup>3</sup>Chem. Zentral. (1919), vol. 4, p. 688. A number of patents covering the preparation of hydro-naphthalenes have been applied for—e.g., International Specifications 147,474; 147,476; 147,478; 147,580 to G. Schroter, Berlin.

smell which it imparts. The higher fractions are used as solvents in purifying anthracene.

#### CREOSOTE OIL AND PITCH

By far the greater percentage of the compounds in coal tar are not worked up for isolation in the pure state, but are sold as constituents of creosote oil or pitch, and it is in these products that the bulk of the tar distiller's business is done. Accordingly uses for these products are extremely important to the tar distiller.

**Creosote Oil.** The term creosote is used in a very broad sense in commercial practice and includes many products which do not have their origin in a byproduct coke plant. In this article the term "creosote oil" will be applied to the residual oils obtained after the crystallization of the naphthalene and anthracene and extraction of phenol and cresols. Such oils form high-grade agents for the preservation of wood or almost ideal liquid Diesel fuel.

Certain purchasers require a creosote containing more naphthalene than the above oil contains. This furnishes an additional outlet for the crude naphthalene, which can be added as desired. The demand for creosote the past few years has been so great that much low-grade foreign material has been incorporated with coal-tar distillates. A favorite mixture is coal tar 20 per cent, coal-tar oil 80 per cent. Mixtures containing water-gas tar are also employed.

**Pitch.** Since the amount of pitch obtained from coal tar is very large (about 50 to 60 per cent by weight of the tar), it is very important to so conduct the distillation that this shall be marketable at its maximum value. For this reason tar distillers generally run to a certain grade of pitch, rather than to a certain percentage of oil, or to a certain vapor temperature.

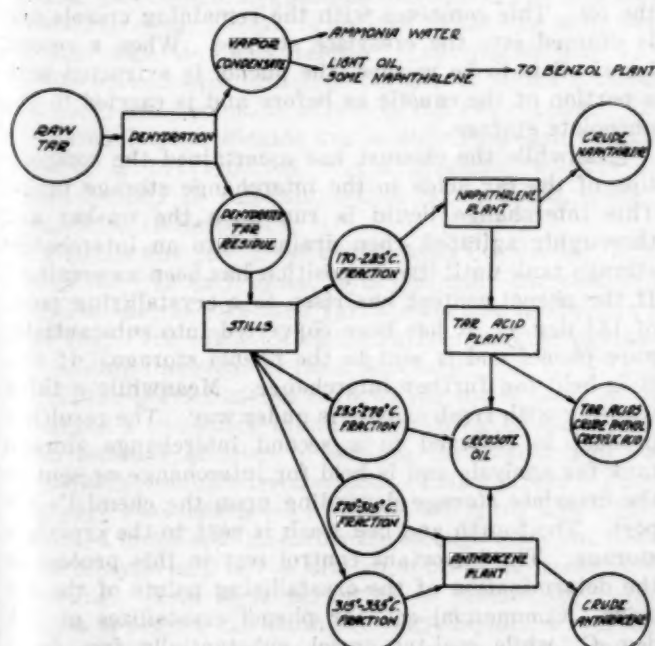


FIG. 1. FLOW DIAGRAM OF THE PROCESS FOR REFINING TAR

Pitch may be graded into three groups: (1) Soft, (2) medium, and (3) hard. These grades of pitch have a great variety of uses, among which may be mentioned:<sup>a</sup>

(a) Roofing.—This use is so well known that it requires only passing mention.

(b) Waterproofing.—Tunnels, bridges, underground construction in general makes important use of pitch as a waterproof binder.

(c) Paving.—Coal-tar pitch has had wide application in the construction of many types of paving. The use of soft pitch as a binder in concrete and tar macadam roads has been extremely important lately. Block and brick pavements use pitch as a filler.

(d) Paints and Protective Coatings.—Solutions of pitch in coal-tar solvents are used for iron and steel, for acid-proofing and alkali-proofing, and for waterproofing.

(e) Pitch Coke.—A comparatively recent development is the demand for pitch coke as a source of carbon for the electrochemical industries. This promises to furnish an outlet for hard pitch.

(f) Miscellaneous.—A great many other uses may be mentioned such as core compounds for casting, as a briquet binder, as a pipe dip, as an insulating medium for electrical purposes and many other purposes.

The exact specifications for the pitches which are to be used for these purposes vary from purchaser to purchaser and are supplied by the purchaser, so they cannot be conveniently given here.

The complete production of pitch may be utilized in the coke plant. A brief discussion of this will be found on a later page.

#### PROCESSES INVOLVED IN THE REFINING OF TAR

The processes involved in the refining of tar take the sequence shown in Fig. 1.

**Dehydration.** The first process in the distillation of tar is that of dehydration. Thick layers of crude tar if suddenly heated will foam and spatter disastrously because of the explosive formation of steam from water droplets dispersed through the tar probably as in an emulsion. To avoid this, the tar is sometimes dehydrated in special apparatus where only thin films are exposed to the source of heat, which may be indirect. In this, the tar is gradually heated until the vapor temperature reaches 170 deg. C., thereby removing most of the water and free ammonia, together with a little naphthalene and a small amount of tar bases and oil.

In a tar distillery operated in conjunction with a byproduct coke plant, the oil is run to the light oil plant. The naphthalene will of course appear in the still residues from the light oil plant.

**The Carbolic Oil Fraction. Naphthalene.** The sequence of the operation upon the first or carbolic oil fraction (170 to 235 deg. C.) is indicated in Fig. 2.

The hot dehydrated tar is run to the stills, where it is further heated and the condensate evolved collected in appropriate fractions.<sup>a</sup> The carbolic oil fraction (170 to 235 deg. C.) first appears. This contains the phenol, the cresols and a large part of the naphthalene. Some pyridine is also present in this fraction. Upon cooling to atmospheric temperatures the oil is usually converted into a semi-crystalline mass which does not flow satisfactorily. For that reason it is pumped from the receiver while still warm and forced into the naphthalene crystallizing pans. Here it is allowed to remain at atmospheric temperature for from 3 to 5 days. The oil, generally brown in color, is then drained as completely as possible. The naphthalene crystals still entrain a large amount of oil, so these are shoveled by hand from

<sup>a</sup>Weiss, *J. Ind. Eng. Chem.*, vol. 8 (1916), p. 841.

<sup>a</sup>It is beyond the scope of this paper to consider in detail the construction and operation of the stills.

the crystallizing tanks and wheeled to the centrifuge, where much of the remaining oil is removed. The crude naphthalene is washed upon the centrifuge with a jet of cold water (about 18 deg. C.). It is then sufficiently pure to meet many specifications for crude naphthalene and may be sold as such. It is coarsely crystalline and somewhat oily, and generally possesses a dirty light brown color. Its melting point varies, but is generally well above 60 deg. C. The impurities are water, oil, tar acids and tar bases.

This crude naphthalene is often further purified. The first operation is recrystallization. The naphthalene is melted and again run into shallow pans. After standing for a few days, the crystals are centrifuged and washed with a stream of cold water. This recrystallized naph-

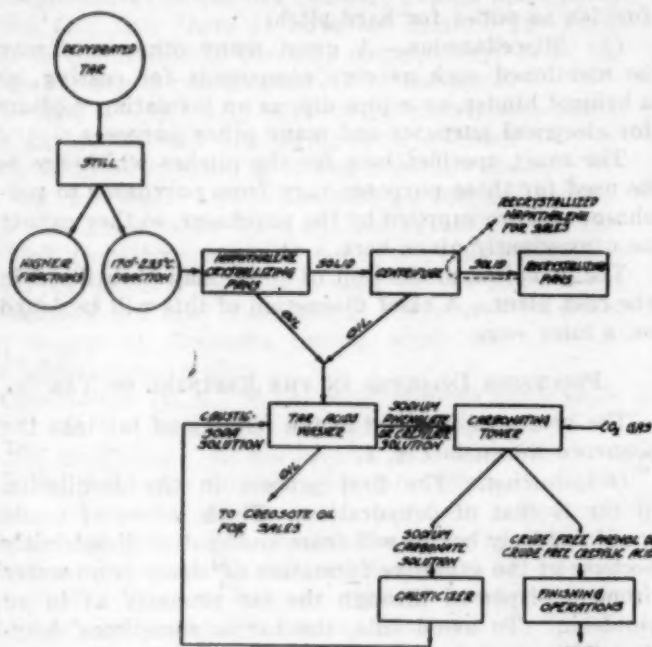


FIG. 2. FLOW DIAGRAM OF THE PROCESS FOR REFINING THE CARBOLIC FRACTION (170 TO 235 DEG. C.) OF TAR

thalene is still brown in color but much lighter than the crude grade described above. The melting point may be raised to 76 deg. C. or higher. The impurities are very much reduced, but still of the same nature as those associated with the crude naphthalene described above.

This recrystallized naphthalene can be converted into pure white naphthalene for balls and flakes by a very simple process. However, most tar distillers do not carry out this final purification, so it will not be described here.

The important control tests are: (1) Dry salt test for determining the content of naphthalene in an oil, (2) melting point tests for the quality of the naphthalene, and (3) distillation of the naphthalene. Water, if present, is also determined.

**Recovery of Tar Acids.** Many tar distillers do not isolate the tar acids as such, but sell instead the oils containing the tar acid. There are a number of modifications of tar-acid recovery, one of which is as follows:

The drain oil from the naphthalene pans and centrifuge used on the 170 to 235 deg. C. fraction is allowed to stand to settle out any ammonia liquor which it may contain, then is run into a suitable washer equipped with agitators. Here it is brought into intimate contact with a solution of caustic soda having an initial specific

gravity of about 1.10 or containing approximately 8 per cent NaOH. The total amount of caustic required depends upon the tar-acid content of the oil and is determined by shaking a sample with increasing amounts of caustic until the oil volume no longer contracts. For tar of the analysis given above, this will not exceed 140 gal. of 8 per cent caustic soda per 1,000 gal. of raw tar.

The tar acids consist mainly of phenol and the cresols, and it is generally advisable to separate these, for in normal times the phenol is of higher value than the cresols. This separation is accomplished by taking advantage of the fact that phenol is a stronger acid than any of the cresols. In the presence of insufficient alkali the phenol will combine with the alkali, while the cresols remain free, or if to cresol already combined with caustic (i.e., sodium cresylate), there is added an oil containing phenol, the phenol will drive out the cresol from its combination and form sodium phenolate instead. The process of washing which utilizes this property of competing and exchanging is known as the "interchange" process and is applied somewhat as follows:

**Interchange Process for Separating Phenol From Cresols.** To the charge of fresh oil in the agitator there is added less caustic than is necessary to combine with all the phenol. (The correct amount can be determined by analysis. The probable ratio is 1 part of phenol to 2 parts of cresol, and the probable caustic use is about one-third the total requirements.) The water-soluble sodium phenolate formed is then drained into the phenolate storage and a fresh portion of caustic added. This will combine with some phenol and some cresol and is held for "interchange" in the "interchange" storage. A third and final portion of the caustic is placed upon the oil. This combines with the remaining cresols and is drained into the cresylate storage. When a second lot of oil is to be washed, the phenol is extracted with a portion of the caustic as before and is carried to the phenolate storage.

Meanwhile the chemist has ascertained the composition of the tar acids in the interchange storage tanks. This interchange liquid is run upon the washer and thoroughly agitated, then drained into an interchange storage tank until its composition has been ascertained. If the phenol content has risen to a crystallizing point of 15½ deg. C., it has been converted into substantially pure phenol and is sent to the phenol storage. If not, it is held for further interchange. Meanwhile a third washing with fresh caustic is under way. The resulting product is reserved in a second interchange storage tank for analysis and is held for interchange or sent to the cresylate storage depending upon the chemist's report. The fourth and last wash is sent to the cresylate storage. The important control test in this process is the determination of the crystallizing points of the tar acids. Commercial coal-tar phenol crystallizes at 15½ deg. C., while coal-tar cresol, substantially free from phenol, does not solidify at -80 deg. C., so it is not difficult to interpret the test and apply it to the interchange process as described above.

In some tar distilleries phenol and cresylic acid are separated without resort to the interchange process. Less caustic than is necessary to combine with the entire phenol content is employed for the first wash, which is of course practically pure phenolate. The remaining tar acids are extracted by a second wash. The

mixture of phenol and cresylic acid subsequently obtained from this second wash is distilled through a column and the first or phenol fraction collected separately. However, the interchange process is preferred, especially in the larger tar distilleries.

The washing process demands efficient agitation, for the caustic soda solution is immiscible with and slightly heavier than the oil. The mixture should be kept warm (30 deg. C., for example). If too hot, the extraction is incomplete; if too cold, naphthalene may separate from the oil and cause trouble, for the tar acids aid in keeping naphthalene in solution and their removal permits the oil to deposit more naphthalene. The agitation is continued for from an hour to an hour and a half.

*Decomposing the Phenolate and Cresylate.*—The phenolate or cresylate is then allowed to settle thoroughly in order to free it as far as possible from the oil. The aqueous phenolate or cresylate is drawn off until an emulsion of oil and water appears in the sight box. To assist in the further removal of oil, the phenolate or cresylate is allowed to remain in the appropriate storage tanks until needed and care is taken not to empty these tanks completely when feeding the carbonating tower. An oily layer gradually collects at the surface of the storage and this must, of course, be cleaned out at rare intervals.

From the storage tank the phenolate or cresylate is passed to the top of the carbonating tower.\* Here it meets in counter-current a stream of gas containing carbon dioxide.

Carbon dioxide is a much stronger acid than either phenol or the cresols and consequently combines with the sodium compound to form sodium carbonate, at the same time liberating the phenol or the cresylic acid.

The gas, which is generally high CO<sub>2</sub> flue gas from coke-fired steam boilers, is purified by passing it through a dust separator and washer. The washer may be a tower packed with limestone chips over which a stream of water flows counter-current to the gas current. This removes sulphur dioxide and a little hydrogen sulphide which, if not removed, would gradually convert the sodium salts to sulphate, which is worthless, since it cannot be recausticized.

Often a flue gas of sufficiently high CO<sub>2</sub> content is not available. In such cases, it is generally the custom to build a special coke-fired furnace for the production of the CO<sub>2</sub>. The efficiency of the furnace may be increased by adding limestone to the coke charge.

At the bottom of the carbonating tower there is discharged a two-phase mixture consisting of spent liquor (an aqueous solution of sodium carbonate) and substantially insoluble free tar acid. This mixture is passed through two separators in series, the spent liquor being drained to the sodium carbonate storage while the phenol and cresylic acid is run into an appropriate receiver for settling. Here it is permitted to remain for several hours to remove the entangled spent liquor. From these settling receivers the tar acid is run in measured quantities to a lead-lined finishing tank to be treated with a measured amount of sulphuric acid. (Generally 60 deg. Bé. or 77 deg. sulphuric acid, sp.gr. 1.7, supplied from an acid tank above.) It is necessary to use this

acid because complete decomposition of the sodium phenolate or sodium cresylate does not take place in the carbonating tower. The sulphuric acid also aids in the removal of water. The acid is added carefully until the mixture changes blue litmus paper red. The tar acid is then tested for its water content in the laboratory, and in case the content is found to be greater than 15 per cent more sulphuric acid is added.

When the tar acid is properly finished, it is separated from the waste sulphuric acid layer by draining this through the sight box. The waste sulphuric acid is run into the waste storage. The crude cresylic acid generally contains some phenol, and it is often redistilled. The still is equipped with a good column, since the cut between phenol (b.p. 184 deg. C.) and ortho-cresol (b.p. 188 to 191 deg. C.) is a close one. A receiver for still residues must be provided, for the still cannot be run completely dry. The still residues are subsequently reworked and may yield as much as 80 per cent cresylic acid, the remainder being pitch and loss. A holder for pitch is also provided. Cresylic acid pitch has no special value and is mixed with the regular coal-tar pitch.

Before shipping cresylic acid, it is submitted to air blowing to "sweeten" it by driving out the hydrogen sulphide which it generally contains. It is then ready for sale.

In order to render this process of extracting tar acids economical, it is necessary to recausticize the sodium carbonate. A high-grade quicklime is used for this purpose. When a special carbon dioxide kiln is used, this produces a lime which can be used in the causticizing.

The oil which has been washed for tar acids is drained free from entangled cresylate solution. It may then be washed for pyridine or again worked up for naphthalene. With naphthalene sales at their present low point, the most economic disposal would probably be to run the drain oil into the creosote and keep the naphthalene in solution by the addition of anthracene drain oils. The 235 to 270 deg. C. fraction generally contains so small an amount of tar acids that it is not worked up for these. It is, however, often worked up for naphthalene. At present, it would probably be pumped into the creosote oil.

*Redistillation.*—Under certain local conditions it is best to submit the fractions containing tar acids and naphthalene to redistillation in order to concentrate these products before submitting the oils to the crystallizing and washing processes described above.

*Anthracene Oils.*—The fractions taken above 270 deg. C. (viz., 270, 315 deg. C. and 316 to 355 deg. C. *supra*) deposit crude anthracene upon cooling.<sup>11</sup> The process of extracting this is very similar to the crude naphthalene process, save that artificial cooling is sometimes resorted to in order to increase the anthracene recovery.

Crude anthracene is dark green to brown in color and possesses a pasty crystalline form. It generally separates in small crystals which hold considerable oil, the whole giving a buttery appearance very familiar to tar distillers. To separate these crystals from oil is some-

\*In some tar distilleries the phenolate or cresylate is decomposed by the addition of sulphuric acid. This process, while less expensive to install and more simple to operate, involves higher production costs, since the sodium sulphate produced is practically worthless and must be thrown away, necessitating the purchase of fresh caustic for each washing for tar acids. It is, therefore, generally used only in small recovery plants and will not be described here.

<sup>11</sup>There is of course no sharp temperature break at which the presence of crude naphthalene ceases and the anthracene solids appear. The oils show a transition in which the content of crude naphthalene progressively declines while the content of the constituents of crude anthracene rises.

<sup>12</sup>The highest temperature attained during distillation varies considerably. The pitch, if overheated, may coke. To obviate this danger, a gas or steam is generally blown through the charge in the last stages and vacuum may be applied.

times difficult. A filter press is generally employed for this purpose.

The pressed crude anthracene cake still contains considerable oil, together with a large amount of other impurities such as carbazol, phenanthrene, acenaphthene, etc., which are solid at ordinary temperatures. The anthracene content is relatively low and may render the product unmarketable as such. It is then necessary to recrystallize it.

This is done by dissolving the first crude anthracene in hot naphthalene drain oil from the 170 to 235 deg. C. fraction. If redistillation of naphthalene oils is practiced, a light, clean redistilled drain oil is used. An excess of the hot oil is mixed with anthracene at a temperature of about 80 deg. C. The proportions sometimes used are 1 ton of pressed anthracene to from 500 to 600 gal. of oil. When all the anthracene has gone into solution in the hot oil, the mixture is permitted to cool to about 20 deg. C. The oil and crystals are then run upon a centrifuge for separation. The crystals are spun until thoroughly dry, washed with cold water, and bagged for shipment. They may contain from 30 to 50 per cent of anthracene. The residual oil is added to the creosote.

With changing local conditions, it is sometimes advisable to depart from the above practice somewhat. There sometimes appears between the naphthalene and anthracene fractions an intermediate fraction whose solids are so impure that they are not worth working up. This fraction is run directly into the creosote. Just above this there may be a fraction which gives a high quality of anthracene (as much as 35 per cent anthracene or higher) merely upon cooling and filtering. This may comprise as much as three-fourths of the remaining anthracene fraction. Still higher there may be a fraction which gives only a low-grade anthracene upon filtering and which must therefore be crystallized from hot naphthalene drain oil in the manner previously described.

**Creosote Oil.**—The character of the creosote oil may be controlled to some extent by the omission of certain fractions and the inclusion of others, by the addition or omission of crude naphthalene, or of the carbolic oil fractions which have not been treated to remove the tar acids. In this manner it is possible to obtain creosotes capable of filling many widely different specifications.

At the present time fuel oil is abundant and not too expensive. However, the time is not far distant when our dwindling oil reserves will probably compel the utilization of tar distillates as a source of liquid fuels. Indeed, those companies which are at present advantageously situated in respect to a suitable coal supply are in a position to obtain such distillates today at a price which compares favorably with fuel oil.

**Pitch.**—The pitch obtained by distilling oil from tar at vapor temperatures higher than 360 deg. C.<sup>12</sup> is generally a hard pitch. It is of course a simple matter to manufacture a softer grade by stopping the distillation at an earlier stage, and by careful regulation secure any commercial grade of pitch.

At a coke plant run in conjunction with a steel works it is generally not necessary to depend upon sales for the disposition of pitch. Thus, with a tar having the analysis given, the distillation may be stopped at the end of the 235 to 270 deg. C. fraction, leaving a soft pitch residue which can readily be liquefied by steam heating, and therefore in every way suitable for use as an open-hearth fuel in place of raw tar, provided only suitable provision for steam preheating be supplied. The oils, naphthalene and tar acids recovered by such a distillation will total about 26 per cent of the volume of raw tar distilled and represent some of the most valuable products of the tar distillery.

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<sup>12</sup>See footnote 12.

### Iron Ore Mined and Shipped in 1921 Estimated by U. S. Geological Survey

The iron ore mined in the United States in 1921, exclusive of that which contained more than 5.5 per cent of manganese, is estimated at 29,547,000 gross tons, a decrease of 56 per cent as compared with the output in 1920. The shipments of ore from the mines in 1921 are estimated at 27,009,000 gross tons, valued at \$89,688,000, a decrease in quantity of 61 per cent and in value of nearly 69 per cent as compared with the shipments in 1920. The average value of the ore per gross ton at the mines for the whole United States in 1921 is estimated at \$3.32; in 1920 it was \$4.11. The stocks of iron ore at the mines, mainly in Michigan and Minnesota, apparently increased from 11,378,794 gross tons in 1920 to 13,872,000 tons in 1921, or 22 per cent.

The output of iron ore in 1921 was the lowest since 1904, when 27,644,330 tons was mined.

The accompanying table shows the quantity and value

of the iron ore mined and shipped in the United States by the principal producing districts. The figures for 1920 are final; those for 1921 are subject to revision.

### French Production and Supplies of Naval Stores

Latest estimates indicate that the French production of naval stores has not been as seriously affected by the summer droughts as was previously predicted, according to information from Consul Jaekel, of Bordeaux, printed in the Jan. 2, 1922, issue of *Commerce Reports*. The total production for 1921 is estimated at 31,000 tons of turpentine and 105,000 tons of rosin, pitch, etc., or 4,000 tons less turpentine and 15,000 tons less rosin than in 1920.

Estimated stocks of naval stores held by merchants and distillers in the Bordeaux region total 1,000 tons of turpentine and 6,800 tons of dry products. The estimated amount in France at the close of 1921 was 7,000 tons of turpentine and 30,800 tons of dry products.

ESTIMATE OF IRON ORE MINED AND SHIPPED IN THE U. S. IN 1921

District	Ore Mined Gross Tons		Ore Shipped Gross Tons		Value	
	1920	1921	1920	1921	1920	1921
Lake Superior.....	57,945,049	25,394,000	59,677,331	23,155,000	\$253,620,578	\$81,091,000
Ala., Ga., N. C., Tenn., Va.....	6,766,794	3,022,000	6,702,730	2,946,000	19,330,818	6,343,000
N. J., N. Y., Pa.....	2,085,959	668,000	2,096,321	444,000	10,266,130	1,278,000
Western.....	740,226	429,000	740,637	429,000	1,460,968	839,000
Conn., Md., Mass., Mo.....	66,437	34,000	64,422	35,000	327,833	137,000
Total.....	67,604,465	29,547,000	\$69,281,341	\$27,009,000	\$285,006,327	\$89,688,000

## Colloidal State in Metals and Alloys. II—Crystallization

Primary Crystallization of Pure Metal Consists of the Coagulation of Very Tiny Crystalline Particles From a Molten Isocolloid—Recrystallization Consists of a Migration of Like Particles Across a Finely Dispersed Solid Mother Liquor Called the Amorphous Phase\*

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**B**EFORE considering the effects of the mechanical and heat treatment of metals and mixtures of metals (alloys), let us first try to follow mentally what happens upon the slow cooling of a hot saturated solution of a crystalloid salt—sodium chloride, for example, since it has no water of crystallization. As the kinetic energy of the system drops and the capacity of the water to maintain the salt molecules (or their ions) in motion diminishes, some salt molecules are extruded as it were from the solution, only to be dissolved again while others are extruded; for there exists a condition, not of static but of kinetic equilibrium, varying with the temperature.

### CRYSTALLIZATION OF SALT SOLUTIONS

If, however, a number of salt molecules are extruded in such a position and so close to one another that they may cohere—i.e., within the radius of molecular attraction—they may form a crystal nucleus, or "crystallogen," which in proportion to its size will tend to take from the cooling solution more extruded molecules than it gives back. Such dominant nuclei tend to form on the relatively cooler walls of the containing vessel or on any added nucleus or foreign surface providing a "rear guard." Quick cooling produces more extruded molecules per unit of time, and agitation tends to bring the extruded molecules into contact; therefore both these factors tend toward the formation of more numerous and smaller crystals. Where large crystals are desired, it is the practice in chemical works to crystallize in large tanks, which are carefully insulated and left undisturbed for weeks.

Extreme care is necessary to grow large perfect crystals from solution, the temperature being controlled within very narrow limits to maintain the slight degree of supersaturation at which no new nuclei or spontaneous crystals will form and yet the seed crystals (or large added nuclei) will grow. R. W. Moore<sup>1</sup> has grown clear, perfectly developed crystals of rochelle salt 3 in. long, the process taking about a month in a thermostat sensitive to about 0.01 deg. C. Of particular interest is his statement that crystals grow faster near the bottom of the crystallizing vessel than at the top, for this is evidence of a gravitational accumulation of molecular groups (nuclei or "crystallogens") at the bottom quite analogous to the separation of the particles in colloidal solutions, as demonstrated by Perrin.

Crystallization continues until there is reached the

kinetic equilibrium corresponding to the final temperature; and we have discrete crystals of sodium chloride bathed in a mother liquor containing a residual amount of salt in solution or true crystalloid dispersion. Impurities tend to collect in the mother liquor, and if they are protectors (in the colloidal sense) may inhibit or modify crystallization as they accumulate, as is the case with molasses, for example.

### CRYSTALLIZATION OF PURE METAL

Even with pure metals under the best conditions, the path of crystallization is not as smooth as is the case with salt solutions, but is beset with complicating factors. There is no foreign restraining solvent, the viscosity is great, the attraction between the closely packed metal molecules is tremendous, and the metal soon forms a hard skin so that the interior crystals are formed under pressure or strain. With some metals there may be formed a geode-like center, where slower cooling and lessened or more equalized strain may result in the formation of large well-developed crystals.

But the metal seldom reaches the crystallization equilibrium, toward which it strives, for the enormous increase in viscosity which accompanies its rapid loss of heat prevents the aggregation tendencies of the metal molecules from entirely establishing themselves, and there results a mass of metallic crystals embedded in a finely dispersed solid metallic "mother liquor," the so-called amorphous phase.

The amorphous phase is colloidal, as its name, appearance and properties indicate, and contains a mixture of submicroscopic crystals or crystal fragments with unoriented or random clusters, possibly in the form of isotropic globulites; for the globulitic form, according to many investigators, seems to be a precursor of the crystalline condition. As stated in the first article in this series, at higher temperatures, before visible crystallization occurs, the whole metal probably exists as an isocolloid. The extent to which this state is altered in the direction of a visibly crystalline mass, embedded in a colloidal matrix, depends largely upon the speed of chilling. In impure metals and in alloys the composition of the phases and the presence of substances which hasten or inhibit crystallization are important factors.

Von Weimarn holds the view, in which the writer does not concur, that all molecules and molecular groups are crystalline, that crystallinity is the only internal state of matter and that in general no amorphous substances exist in nature. This view would give to the words "amorphous" and "crystalline" significations they do not at present possess. Besides the X-ray spectroscopy shows<sup>2</sup> that many organic colloids, such as gelatin and starch, and also some inorganic colloids (silicic acid

\*Part I, on Molten Metal, appeared in *CHEMICAL & METALLURGICAL ENGINEERING*, vol. 26, No. 2, p. 54, Jan. 11, 1922.

The present series of papers was written mainly in the fall of 1919. Reduced to about half their original form, they were read before the Columbus meeting of the American Institute of Mining and Metallurgical Engineers, October, 1920, and will so appear in vol. 64 of its *Proceedings*. They are now given in full, together with some recent additions which are indicated by enclosure within square brackets [ ].

<sup>1</sup>J. Am. Chem. Soc., vol. 41, p. 1010 (1919).

<sup>2</sup>Scheerer, *Nachr. Ges. Wiss. Göttingen*, vol. 96, p. 100 (1918); *Chem. Abs.*, vol. 13, p. 2624.

and stannic hydrosols) consist of or contain groups of molecules arranged in an unoriented, haphazard or random manner; so that even if the molecules themselves are crystal prototypes, they can and do occur in non-crystalline groups.

Zay Jeffries<sup>4</sup> has shown that with metals, in general, the cohesion of the amorphous phase equals that of the crystalline phase at the lowest recrystallization temperature, which he terms therefore the equicohesive temperature; and based on this he has explained the mechanical behavior of metals at various temperatures. At higher temperatures than the equicohesive point, the cohesion of the amorphous phase decreases more rapidly than that of the crystalline phase—i.e., it becomes relatively softer—whereas at lower temperatures than the equicohesive point its cohesion is greater and increases with much greater rapidity than that of the crystalline phase. Fig. 1, taken from Jeffries' paper, shows these facts diagrammatically.

These differences between the two phases are intelligible from the following considerations: The atoms in the crystalline phase, though arranged in regular layers, are on the average closer packed,<sup>5</sup> and therefore at lower temperatures cannot draw together as much as those of the amorphous phase, which consequently becomes relatively stronger at lower temperatures; whereas at higher temperatures, the molecules of the amorphous phase become separated and mobile more readily than those of the crystalline phase, for they possess initially more potential energy<sup>6</sup> since they are less closely packed—i.e., further apart on the average—and are, therefore, less strongly held to one another by molecular forces; consequently the amorphous phase becomes relatively weaker at higher temperatures. The fact that, even at room temperatures, some of the molecules of some metals possess mobility was demonstrated by Roberts-Austen, who showed that gold and lead when placed in contact diffused into each other after a lapse of years.

#### RECRYSTALLIZATION

As a result of this preferential softening, the amorphous or colloidal phase, at relatively higher temperatures, acts like a very viscous solvent surrounding and nourishing the more rigid crystals; and as increasing temperature renders this solvent less viscous, the metal strives toward crystallinity, which represents the position of minimum mechanical potential. Some metals, like lead, undergo such molecular readjustment, even at room temperatures. During this process of recrystallization below the melting point it has been observed that, in general, large crystals tend to grow at the expense of the small ones. A similar process is observable in the crystallization of salts, for, as Hulett has shown, finely ground powders are more soluble than a coarse grinding of the same substance. Therefore the smaller metal crystals would preferentially dissolve in the "amorphous" or colloidal phase. Bearing in mind that the growth of a crystal means that there are deposited upon it more molecules or molecular groups (crystallogens) than are dissolved off, the larger masses would naturally get most of these extruded units, just as happens in the cosmic field. The larger crystals

have the advantage of exposing to the solvent action of the amorphous or colloidal phase less surface per unit of mass; and when metal molecules or molecular groups deposit on a crystal, they release a certain amount of energy, the heat of crystallization or latent heat of fusion, which helps to make the amorphous or colloidal phase more fluid.

Do the small crystals dissolve molecule by molecule, or in molecular masses or groups as well? It would seem that in some cases at least molecular groups are dissolved off and transported, for in strained metals especially recrystallization is extremely rapid. Thus in sheet aluminum<sup>7</sup>, when heated to a suitable temperature, recrystallization takes place like a flash, the originally smooth sheet becoming coarsely granular, suddenly, before one's eyes. The writer has observed<sup>8</sup> ultra-microscopic particles streaming from a crystal of

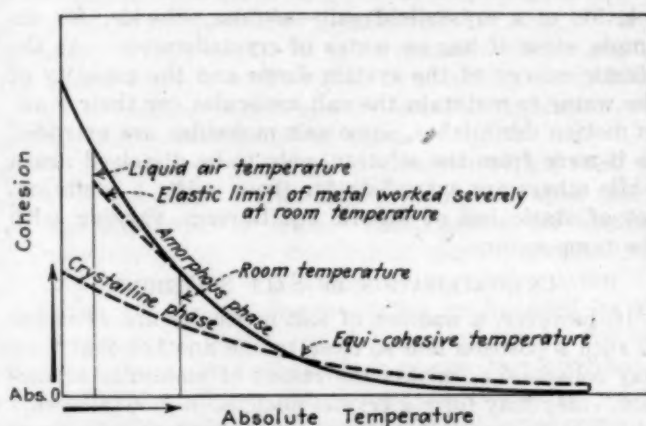


FIG. 1. DIAGRAMS SHOWING CHANGE IN ELASTIC LIMIT AND HENCE DUCTILITY OF A METAL SEVERELY WORKED AT A CERTAIN TEMPERATURE AND TESTED AT AND BELOW THAT TEMPERATURE

sodium citrate as it went into solution, indicating that initially solution took place, at least partially, in colloidal molecular masses.

The amorphous or colloidal phase becomes, therefore, a medium for the transfer of atoms, molecules or molecular groups from the small to the larger crystals, and also tends to annihilate itself by allowing its constituent oriented and unoriented particles to be incorporated into the huge Juggernaut crystals.

The preceding remarks have been based upon a consideration of pure metals, which are practically never met with, for most commercially pure metals contain as impurities several other metals, elements or compounds. Besides, most metals are used in the form of mixtures or alloys—steel, brass, bronze, type-metal, babbitt metal, solder, etc. The introduction into a metal of a single impurity, even in minute percentage, usually produces a very marked change in its properties or behavior—for example, 1 part of carbon in 10,000 of iron, or 1 part of copper in 10,000 of gold—and as it seems to me that in many cases this effect involves, at some stage, the direction, modification or inhibition of the normal crystallization of the metal by a colloidal dispersion of some substance or substances, it is desirable at this point to consider the general question of the effect of colloids upon crystallization.

Most experiments in this field have been made with aqueous solutions or dispersions, and the rule seems to

<sup>4</sup>J. Am. Inst. Metals, vol. 11, p. 300 to 324 (1917). See also J. Inst. Metals, vol. 20, p. 109 to 140, and Trans. Am. Inst. Min. Eng., Bull. 146, February, 1919.

<sup>5</sup>Pope and Barlow. The intrinsic weakness of the crystal lies in its tendency to rupture along lines of slip or cleavage.

<sup>6</sup>As Graham said, colloids possess energy.

<sup>7</sup>Dr. G. H. Gulliver, J. Inst. Metals, vol. 20, p. 158 (1918).

<sup>8</sup>Alexander and Bullowa, "Archives of Pediatrics" (1910).

be that a colloid which is adsorbed by, or which forms an adsorption compound with, the initial colloidal aggregations of the crystallizing substances either prevents the growth of its crystals or groups beyond colloidal dimensions or else forces their growth to assume globulitic or dendritic forms which vary with each substance, each colloid and each set of conditions. Thus gelatin, gum arabic and similar stabilizing or protective colloids, even in small quantity,<sup>9</sup> oppose the aggregation of the gold atoms at the instant of their liberation to such an extent as to yield a highly dispersed hydrosol under conditions that would otherwise yield a coarse blue or black gold suspension. The use of gelatin (about 1 per cent), eggs and similar colloids in ice cream<sup>10</sup> leads to the production and stabilization of very fine or colloidal ice particles, giving the product the desired smooth velvety texture; without colloids the ice cream becomes grainy or sandy, the undesirable roughness being due to large or spicular crystals.

Coming now to substances which form solid crystals at ordinary temperatures, we see in Table I that colloids exert a powerful inhibitory action on the crystallization of plaster of paris,<sup>11</sup> not only preventing the formation of ordinary crystals but delaying or even entirely preventing the "setting."

TABLE I. EFFECT OF GELATIN ON PLASTER OF PARIS

1 Part Plaster to 1 Part Water Con- taining Gelatin per Cent	Time to Set in Minutes	Microscopic Appearance of Slide Characteristic crystals of calcium sulphate.
0	40	
1/100	50	No crystals, except in a few spots where some colloid-free solution had diffused out.
1/10	260	No crystals.*
1/4	510	No crystals.*
1/2	960	No crystals.*
1	Not set in 48 hr.	No crystals.*
2	Not set in 48 hr.	No crystals.*

\*No regular, ordinary crystals, the mass consisting of aborted, modified or spherocrystals, or of colloidal crystals or other minute unoriented groups, or of a mixture of these.

The effect of colloids on the crystallization of ordinary salts is most remarkable<sup>12</sup> and I hope to be able to publish further results of experiments along this line. Meanwhile I may say that with each salt, each colloid and each set of conditions (concentration, temperature and pressure) there are formed characteristic groupings in which dendrites and spherulites are exceedingly common; also very beautiful and complicated leaf-like, branching and cellular forms, reminding one forcibly of living structures. Indeed it seems evident that the growth and shape of living organisms are largely controlled by the complex interplay of the forces of crystalline growth, as restrained, modified and directed by colloidal substances.

If the amount of colloid is so small that it is all adsorbed by these structures before the salt has entirely crystallized, well-defined crystals of the colloid-free salt may appear. On the other hand, if enough of the colloid is present, ordinary visible crystallization may be entirely prevented; and in intermediate cases abortive attempts at crystallization register themselves in curious formations. The preparation of a few microscopic

slides with solutions of NaCl, MgSO<sub>4</sub>, Na<sub>2</sub>SO<sub>4</sub> and Na<sub>2</sub>CO<sub>3</sub>, containing from 0.5 to 50 per cent (figured on the dry salt) of gum arabic or gelatin, will give some idea of these effects<sup>13</sup> and show their striking resemblance to the microstructure of metals. The slides may be made by putting on a drop of the mixture and allowing it to dry without a cover glass. During the drying, changes in temperature and concentration occur within the drop, with the result that the field changes progressively from the center.

#### PRODUCTION OF FINE GRAIN

This resemblance led me to comment<sup>14</sup> as follows regarding metals: "Since coarsely crystalline metals are brittle, tending to split along the lines of crystal cleavage, various physical and chemical means are employed in technical practice to obtain a hard, fine-grained structure." Among the physical methods are chilling and rolling, while the chemical methods involve the removal of undesirable constituents (as in the conversion of pig iron into steel), or the addition of desirable constituents (as in case-hardening and the manufacturing of 'chromium steel' and 'nickel steel'). For example, P. Pütz<sup>15</sup> has shown that the predominant effect of vanadium in steel is to decrease the size of the ferrite grains and make the material harder; it renders the ordinary structure due to pearlite fine-grained and homogeneous."

"Now while the question is one of very great complexity, many of the facts at present available seem to indicate that one of the causes favoring the fine-grained structure is the inhibition of crystallization by substances colloiddally dissolved in the molten mass. Thus, part of the carbon in iron and steel exists in the graphitic form, and as graphite is slightly soluble in iron<sup>16</sup> some of it will, under proper conditions, be found in colloidal form." Besides, metals may dissolve one another and other substances colloiddally, but in the case of ordinary metals this is not easy to demonstrate, although a differential solvent acting in the presence of a protective colloid might leave a colloidal residue."

#### AMORPHOUS METAL AND COLD WORK

In conclusion let us consider some of the aspects of the amorphous theory regarding the change of metals under strain, which is stated by one of its principal advocates, Rosenhain, as follows<sup>17</sup>:

"It may be well to state precisely what is understood, in this connection, by the term 'amorphous.' In accordance with Beilby's views and their recent development by the author [Rosenhain] and his collaborators,<sup>18</sup> the amorphous condition is one in which the crystalline arrangement of the molecules is completely broken up, so that the molecules remain in a state of irregular arrangement similar to that which is supposed to exist in the liquid state. In fact, the amorphous phase is re-

<sup>12</sup>A mixture of Na<sub>2</sub>CO<sub>3</sub> and NaCl crystallized in the presence of gelatin may form a "flowering plant," the Na<sub>2</sub>CO<sub>3</sub> forming gracefully curved "stems" and the NaCl characteristic four-petaled "flowers."

<sup>13</sup>J. Soc. Chem. Ind., vol. 28, p. 280 (1909).

<sup>14</sup>See P. Longmullr, J. Iron and Steel Inst., September, 1907; J. Soc. Chem. Ind., vol. 26, p. 1064 (1907).

<sup>15</sup>J. Soc. Chem. Ind., vol. 26, p. 614 (1907).

<sup>16</sup>See also Beilby, Proc. Roy. Soc. A., vol. 79, p. 463; J. Soc. Chem. Ind., vol. 26, p. 926 (1907).

<sup>17</sup>See C. Benedicks, Metallurgie, vol. 5, p. 41 (1908); J. Soc. Chem. Ind., vol. 27, p. 406 (1908).

<sup>18</sup>Carnegie Research Reports, J. Soc. Chem. Ind., vol. 27, p. 570 (1908); F. Wüst, J. Soc. Chem. Ind., vol. 26, p. 412 (1907); Hersey, J. Soc. Chem. Ind., vol. 27, p. 531 (1908).

<sup>19</sup>"Introduction to Physical Metallurgy," p. 249.

<sup>20</sup>Rosenhain & Ewen, J. Inst. Metals, vol. 8, No. 2 (1912) and vol. 10, No. 2 (1913). Rosenhain and Humphrey, J. Iron and Steel Inst. 1913, 1.

<sup>9</sup>Excessively minute quantities may have the contrary effect and actually sensitize. While this condition has not been observed in metals, it evidently forms the basis of the phenomenon known to physicians as anaphylaxis.

<sup>10</sup>J. Alexander, Koll. Zeit., vol. 4, p. 86 (1909).

<sup>11</sup>Jerome Alexander, J. Soc. Chem. Ind., vol. 28, p. 280 (1909).

<sup>12</sup>J. Alexander, Koll. Zeit., vol. 4, p. 86, (1909).

garded as being—from the point of view of the phase doctrine—identical with the liquid phase. Now extremely undercooled liquids are well known in such substances as glass, vitreous silica, etc., and they are hard, brittle bodies devoid of plasticity and of crystalline structure. Amorphous metal is, therefore, to be regarded as being identical in nature with the liquid metal if that could be cooled down to the ordinary temperature without undergoing crystallization. It is admitted that such extreme undercooling of metals has never been actually accomplished, and objections to the whole concept of amorphous metal have been based on that ground. These cannot be discussed here, but they have been fully dealt with by the author [Rosenhain] elsewhere.<sup>11</sup> At the present moment it may well be claimed that the theory of an amorphous phase in metals, produced as a result of mechanical disruption of the crystalline arrangement of the molecules, holds the field as the best working hypothesis available. There are admittedly outstanding difficulties, but these the author regards as being inevitable in a theory whose wide generalizations cover a field which has as yet been but partially explored.<sup>12</sup>

#### EFFECT OF PLASTIC DEFORMATION

"The general effect of slowly applied or 'static' plastic deformation may be summarized as follows: The metal in the cast or the annealed state is an aggregate of crystals; when the metal undergoes plastic deformation, the crystals are deformed in the same general sense as the mass of metal. This change of shape of the crystals is accomplished by a process of slip or gliding by which layers of the crystal slide over one another along certain gliding planes. Such slip occurs on a great multitude of planes in each direction and, as a rule, it must occur on at least three sets of planes, but it may occur on a greater number. This slip is accompanied by a certain disturbance of the crystalline arrangement of the molecules on or near the surfaces of the slip. If the deformation has been slight, the disturbed molecules may be able to rearrange themselves in accordance with the crystalline system by which they are surrounded, and the completely crystalline character of the metal will then be unaffected by the deformation. When the deformation is severe and if it is intensely localized, as when a single crystal is bent upon itself, the molecular disturbances at the slip surfaces become larger and permanent layers of amorphous metal are formed on each surface where slip has occurred. Ultimately the metal, as a result of extreme deformation, becomes a mass of crystal fragments embedded in relatively thick layers of amorphous material. This change is accompanied by an increase in the hardness of the metal and—in the majority of metals—by a measurable decrease in density."

This amorphous view stresses particularly the entire absence of regular orientation or crystallization in the so-called amorphous phase, whose molecules are supposed to be in the random and, mainly, isolated state assumed to exist in liquids. I believe, however, that the amorphous phase consists largely, if not entirely, of molecular groups, many of which may be oriented in the form of ultramicroscopic crystals or crystal fragments; and

that its properties are due, not to the entire lack of orientation among its particles, but rather to the fact that many or the majority of its molecular groups are of colloidal dimensions. Since in metals the molecules are very close together and possess extremely high cohesion or crystallization tendency, it does not seem possible that the amorphous phase can be composed entirely of isolated molecules, or even entirely of non-crystalline groups. With gold hydrosols where the dispersing water exercises a restraining influence, the X-ray spectroscopy shows that the ultramicroscopic, and even that the amicroscopic, gold particles are crystalline. With the most drastically chilled metal, allowing for the high viscosity and its rapid increase, it does not appear conceivable that no tiny ultramicroscopic crystals form, or at least that there is no grouping, regular or irregular, of the metal molecules. The facts indicate and are in harmony with the conception of amorphous metal as an isocolloid—that is, as a dispersion of colloid crystals, crystal fragments or non-crystalline groups in still more finely dispersed metal—or else a mixture of colloidal crystalline and non-crystalline groups, forming a solid gell-like mass. The fineness of its particles and the enormous development of free surface found in all colloids are its critical factors.

The idea here advanced, that metals, in the course of their aggregation, pass through a colloidal stage which exerts a powerful influence on their structure and properties and may even be partly retained in the final product by "protection," adsorption, crystallization or increase in viscosity due to quenching, is not limited to the field of metallurgy, but may be applied to any substance or system where a portion or a component becomes colloidal while the remaining portion or components are outside of the colloidal zone. The case of glass has been mentioned in the first article of this series, where some components apparently inhibit the ordinary crystallization of the others under operating conditions. This theory may also account for the fact that under one set of conditions  $\text{Na}_2\text{CO}_3$  crystallizes with ten molecules of water, while under other conditions it may be crystallized with seven molecules of water; and the effloresced crystals hold only one molecule of water. Sodium sulphate acts similarly, forming  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ ,  $\text{Na}_2\text{SO}_4 \cdot 7\text{H}_2\text{O}$  and the anhydrous salt  $\text{Na}_2\text{SO}_4$ .

#### INFLUENCE OF ATOMIC GROUPS

Liquids appear to consist largely of atomic or molecular groups and solids of still more complex groups, the size and nature of which depend upon conditions<sup>13</sup>; and among these groups those of colloidal dimensions as a rule appear and must then be reckoned with. The "twinning" of crystals,<sup>14</sup> which is a marked characteristic of  $\gamma$  iron,  $\alpha$  brass, and especially of worked or strained metals on annealing, is probably due to colloidal influences.

This and many other questions, such as the effect of other metals on iron and steel (so-called alloy steels) and the adsorption of gases at the free metallic interfaces, etc., though germane to this paper, must be left

<sup>11</sup>Rosenhain, *Engineering*, October, 1913. *Internat. Zeit. Metallographie*, vol. 5, 1914.

<sup>12</sup>Heyn, "Report on Progress of Metallography From 1910 to 1913," *Internat. Testing Assoc. N. Y. Congress*, 1912. *Tammann. Zeit. Elektrochim.*, vol. 18, July, 1912. *Guertler, Internat. Zeit. Metallographie*, vol. 5, 1914.

<sup>13</sup>W. E. S. Turner ("Molecular Association," p. 99) says: "The formula of a substance shall be recognized as a function of the physical conditions under which it exists, so that the formula for elements is  $X_n$ , for compounds  $(XY)_n$ , where  $n$  is to be specified according to the conditions. Although we are far from realizing how  $n$  varies for most substances, the adoption of such formula would bring home clearly the fact that both the physical and the chemical behavior of a substance may be closely dependent on the value of  $n$ ."

<sup>14</sup>[See paper by P. Niggli, *Koll. Zeit.*, vol. 10, p. 268, entitled "Colloid Chemistry and Twin Crystals."]

for future consideration. The work of P. W. Bridgman<sup>2</sup> with high pressure is very suggestive. For example, he found that, whereas cylinders of soft tool steel (1.25 per cent C) and soft chromium-nickel steel (Krupp Special E.C. 60.0) ruptured under the same pressures, whether water or mercury was the pressure-carrying fluid in contact with the metal, the same steels when hardened broke at much lower pressures (about one-third) with mercury than with water. The rupture was due to the amalgamation of the steel, which when once started spreads rapidly under the high hydrostatic pressure.

But even a pressure of 6,500 atmospheres for 12 hours failed to cause the amalgamation of hard or soft steel rods, although the rods were polished with fine emery paper immediately before being plunged into the mercury. On the other hand, hard and soft steels and cast iron (also Al, Ni and Co) were promptly amalgamated on the fresh surfaces formed by breaking the metals under mercury.

Bridgman speaks of "dirt" preventing amalgamation; but from the recent work of W. B. Hardy, on fresh surfaces, and of I. Langmuir and others, on adsorption, it would seem that instantaneous adsorption from the atmosphere, probably of gases, is responsible, although a change in the nature of the surface may have some effect also. Freshly cleaved sheets of mica show a similar effect; their initial coherence is speedily lost. With steel, as with gelatin jellies, the quickly chilled specimens show greater porosity because of the greater total area of the diffusion paths consequent upon finer subdivision. (*Part III, dealing with White Metal and Brass, will appear in a subsequent issue.*)

## Need for a Scientific System for the Evaluation of Gelatin and Glue

DR. R. H. BOGUE, of the Mellon Institute of Industrial Research, speaking before the New York Section of the American Chemical Society on Jan. 6, stressed the very evident need for a better and more logical system for determining the value of gelatin and glue. Evaluation methods, which have been used in the past and are still adhered to, do not adequately differentiate these products. There are three fundamental reasons for this.

### THREE FAULTS OF PRESENT SYSTEM

First, the methods of grading do not at present invariably get at the real property or properties which mean value. They are usually aimed in the right direction, but too often fail in attaining the end desired. A gelatin or glue costing 50c. may, by the present system, be judged inferior in gelatin content or in sticking qualities to one costing 45c. This is not the fault of the manufacturer or the jobber, but is rather a reflection on the chemist for not providing the former with a truly representative system for evaluating his product.

Second, there are so many systems now in use for designating quality—in fact, nearly every glue house in the country uses somewhat different methods—that it becomes almost hopeless to attempt to specify a desired product by any symbol and be certain that a product of the desired properties will be obtained. The same specifications sent to a number of glue houses

will not result in the selection by them of exactly equivalent lots, and the several lots obtained will not be equivalent in binding strength or in gelatin content. The standards for reference are inadequate. A viscosity of 45 in one house may be the equivalent to a viscosity of 100 in another house due to the employment of different instruments, or different temperatures, or different concentrations.

Third, an inevitable consequence of this system, and which reacts to the advantage of the manufacturer, is the confusion of the consumer. It leaves too wide a margin upon which the unscrupulous salesman may play. There being no standard of quality, there can be no standard of price that is sufficiently conspicuous to the consumer to make impossible the "putting over" on him of questionable deals.

It should be possible to establish specifications in gelatin and glue that are comprehensive and intelligible, and every such effort should be given careful consideration. From among the many suggestions, a competent committee of chemists should select one, or some combination, that shall be established as a standard.

### PROPOSES VISCOSITY AS BASIS FOR PRIMARY EVALUATION

Dr. Bogue has studied the fundamental relations between gelatin content and adhesive strength on the one hand, and jelly strength, viscosity and melting point on the other hand. He has found that a differentiation by noting the melting points is also expressive of the differentiation in the gelatin content and the adhesive strength. The gelatin content is a fundamental property and the adhesive strength is the most important practical property of glues. Since these are not easily determined, but are found to be proportional to the melting point, the latter is a satisfactory test upon which to base grade.

But the melting point test is tedious and not well adapted to control work in a large plant. It was found that the viscosity at a temperature of 32 deg. C. and a concentration of 20 per cent made by the MacMichael viscosimeter differentiated gelatins and glues in the same order as the melting point, and was especially well adapted to plant control work. The instrument is a standard one and obtainable from any chemical supply house; its readings may be expressed, without any calculation, in absolute degrees or centipoises. Thus we have a specification in a universal language, upon a standard instrument, that is representative of actual quality, and that is readily adaptable to plant practice. This, according to Bogue, should constitute the primary basis for evaluation.

Secondary tests, also expressed in some standard language, may be made to determine the adaptability of the product to a given service. These include the customary tests for foam, grease, reaction, etc. A test for hydrogen-ion concentration should be added, as the properties of the product vary with this factor.

The designation of grade may well be expressed in terms of the viscosity in centipoises (or more conveniently in centipoises divided by ten) of the material as shown in the test outlined above. This number could be used as a subscript to a letter referring to the origin of the material. Thus products designated as H<sub>130</sub> and B<sub>130</sub> would refer respectively to a material from hide having a viscosity lying between 130 and 139 centipoises and to a material from bone having a viscosity between 160 and 169 centipoises.

<sup>2</sup>See "The Action of Mercury on Steel at High Pressure," *Proc. Am. Acad. of Arts & Sciences*, vol. 46, pp. 325-341 (1911); also subsequent papers.

## The Bucher Process for the Fixation of Nitrogen\*

An Account of Small- and Large-Scale Experiments in the Production of Sodium Cyanide From Soda Ash, Carbon and Iron—Comparison of Results With Those of Other Investigators—Details of Furnace Design

BY M. DEKAY THOMPSON

THE fixation of nitrogen by means of the reaction  $\text{Na}_2\text{CO}_3 + 4\text{C} + \text{N}_2 = 2\text{NaCN} + 3\text{CO} - 138,500$  calories in the presence of iron as catalyzer and at a temperature of about 1,000 deg. C. was discovered by Lewis Thompson in 1839, but on account of the extensive research carried out by Prof. John E. Bucher<sup>1</sup> in recent years on this reaction it is commonly known as the Bucher process.

During the war a plant was built by the government at Saltville for the purpose of making cyanide by this reaction.<sup>2</sup> The briquetted mixture of soda ash, carbon and iron was heated in ferrochromium tubes 9 in. in diameter by means of gas, and the charge was passed continuously through these pipes. The plant was not running at full capacity at any time and was shut down when the armistice was declared. As far as is known, there is at present no plant operating commercially according to this process. Besides the article by Bucher referred to above, shortly after the present work was begun there appeared an article by Ferguson and Manning<sup>3</sup> in which it was shown that the reaction is reversible and the quantity of cyanide formed depends on the amount of carbon monoxide in the nitrogen-carbon monoxide mixture in contact with the solid substances of this reaction. Bucher states in his paper that just as good results are obtained with air which has been passed over hot carbon as with pure nitrogen. This statement is evidently incorrect. It was also found that for a given percentage of carbon monoxide in the gas a higher cyanide yield was obtained at 1,000 deg. C. than at 940 deg., which is of course a necessary consequence of the fact that heat is absorbed in the formation of cyanide. Two other articles on the Bucher process may be mentioned. Posnjak and Merwin<sup>4</sup> find some nitrogen compound other than sodium cyanide in the crude technical product, and confirm Bucher's reaction given above. Morimoto<sup>5</sup> easily obtains yields of 75 per cent, using iron turnings and charcoal at 820 to 950 deg. C.

It was found necessary in the course of this work to do a considerable number of experiments on a small scale on account of the unsatisfactory yields of cyanide obtained in the first experiments when the mixture was made from metallurgical coke and iron flour. These were supposed at the time to be the proper materials. Furthermore, the briquets in many cases

became very soft or fell to powder on the treatment with nitrogen, and it was necessary to find some way of preventing this disintegration. These experiments will be described first.

### PROCEDURE IN SMALL-SCALE EXPERIMENTS

The briquetting was carried out in a meat chopper as described by Bucher after mixing hot in a Werner & Pfleiderer mixer and the briquets were dried in covered iron pots, heated by a bunsen burner. A few experiments were made with briquets of  $\frac{1}{8}$  in. diameter, the majority with briquets of  $\frac{1}{4}$  in. diameter, but the diameter was not found to have any effect on the result. The heating in nitrogen was done in vertical tubes. In the preliminary experiments a steel tube of 1.25 in. inside diameter and 2 ft. in length was heated by a resistance coil which was insulated from the tube by a sheet of asbestos, and also heat-insulated on the outside. In later experiments iron pipes of  $1\frac{1}{8}$  in. inside diameter,  $1\frac{1}{4}$  in. outside diameter and 5.5 ft. long were used, holding about 600 g. of briquets. These were heated by passing an alternating current through the pipe. The lowest voltage available was 10 volts, which gave 2,400 amp. when the pipe was cold and 1,600 amp. when hot. The temperature was regulated by opening and closing the circuit at short intervals approximately of 1 minute duration. This was equivalent to a continuous input of about 2 kw.

These pipes were heat-insulated with asbestos pipe covering somewhat too large to fit the pipe, and the space between the pipe and the covering was filled with loose asbestos-magnesia mixture. The temperature of the outside of the pipe was taken at regular intervals at five points along the tube by a platinum-platinum rhodium thermoelectric couple protected by silica tubes. These tubes were inserted through the asbestos pipe covering and carried in direct contact with the iron tube. Repeated comparisons between the indications of the couple and of an optical pyrometer showed that the couple read about 80 deg. lower than the temperature of the pipe. All readings were corrected accordingly. The temperature of the briquets inside the iron tube may have been a few degrees below the temperature of the tube itself, but no comparison was made. The briquets were held up by an iron gauze placed inside the tube. The nitrogen was taken from a tank of highest grade nitrogen, and was measured by an ordinary house dry gas meter. The tube was filled with briquets through that portion of its length which was heat insulated, then with nitrogen, and the current applied. The exit gas was lighted, and when the flame would no longer burn (in later experiments analyses for carbon monoxide were made until the absence of the gas showed the reaction was complete) the pipe covering was removed, and the tube permitted to cool

\*This research was carried out for the U. S. Smelting, Refining & Mining Co. The author wishes to express his thanks to this company for permission to publish these results.

<sup>1</sup>J. Ind. Eng. Chem., vol. 9, pp. 233-252 (1917).

<sup>2</sup>Brown, J. Ind. Eng. Chem., vol. 11, pp. 1010-1013 (1919).

<sup>3</sup>J. Ind. Eng. Chem., vol. 11, pp. 946-950 (1919).

<sup>4</sup>Eugen Posnjak and H. E. Merwin, "Notes on the Bucher Cyanide Process for the Fixation of Nitrogen," J. Wash. Acad. Sci., vol. 9, p. 28 (1919), abstracted in Chem. Abs., vol. 13, p. 891 (1919).

<sup>5</sup>Y. Morimoto, "The Fixation of Nitrogen as Cyanide," Kogyo-Kwagaku Zasshi (J. Chem. Ind. Japan), vol. 21, p. 881 (1918), abstracted in Chem. Abs., vol. 13, p. 363 (1919).

with a small current of nitrogen passing through it. The charge was removed when cool, divided into a top, middle, bottom and average portion, ground, and analyzed for cyanide by titrating with nickel sulphate,\* and for total alkali by titrating with sulphuric acid, using methyl orange as indicator.

The temperature of the pipe was usually between 940 and 1,040 deg. C. In some pipes there was excessive local heating, and in this case the pipe was rejected.

It may now be interesting to compare some of Bucher's results with those obtained in these experiments.

#### COMPARISON WITH BUCHER'S RESULTS

In Bucher's experiments, No. 5, made with graphite, iron and sodium carbonate, the flame was colorless, while in No. 4, where the iron was omitted, the flame was yellow colored. Bucher takes this as evidence "showing that no sodium was formed when iron was present." In the present experiments, where iron was always present, the cool top of the tube frequently had an incrustation which contained metallic sodium. On throwing it into water it reacted violently and sometimes took fire. At

TABLE I. EFFECT OF GRINDING PETROLEUM COKE AND IRON  
(Iron flour contained 91 per cent iron. Analysis of dried briquets: 21.3 per cent iron, 29.5 per cent soda ash. Duration of each experiment: one hour.)

No.	Hours Grinding	Deg. C.	Per Cent of Cyanide	Average Conversion in per Cent
15	11	950-1,050	2.7	20.5
16	57	950-1,050	12.2	47.0
17	72	950-1,050	16.0	61.5
18	15	950-1,050	7.0	41.5
19	23	1,050	12.0	53.6
20	30	1,050	7.4	51.0
21	30	1,050	8.7	*49.2
22	70	1,050	8.4	39.0

\* Duplicate of No. 20.

the same time the flame was colorless, consequently a colorless flame is no evidence that small amounts of sodium are not produced at the same time that cyanide is formed.

Bucher does not discuss the question as to what composition produces a hard briquet after treating with nitrogen. In the present experiments it was found that the briquets increased in hardness when the content in alkali and iron was increased at the expense of the carbon. Briquets which after heating analyzed about 80 per cent iron plus total alkali (with the iron and alkali in about equal amounts) were hard, while if this sum was only 70 per cent, the briquets were nearly always soft. This would correspond to about 24 per cent iron as  $\text{Fe}_2\text{O}_3$  and 29 per cent soda ash in the dried briquets before the run.

The percentage of sodium converted to cyanide is one of the most important factors in this process. The results obtained on this point may be stated in a very few words: (1) The finer the particles of iron and carbon the higher the conversion of the sodium to cyanide (or the "purity," as Bucher calls it), and (2) the highest results were obtained with those forms of carbon that had very little ash, such as petroleum coke, lamp-black, graphite, gas carbon and charcoal. Coke with 10 per cent ash gave very poor results, as shown below. The effects of prolonged grinding in a ball mill are shown in Table I.

These results are apparently contradictory, for in Nos. 15 to 17 there is a continued increase in conversion with the duration of the grinding, while in Nos. 18 to 22 the conversion first increases and then decreases. The

only difference in the procedure in the two series was that in the first a small ball mill of about 2 liters total capacity was used, in the second a large one about 2 ft. in diameter. Steel balls were used in both mills. This question was not pursued further, for better results were obtained without excessive milling.

The conversion in these runs was decidedly low, and it was evident no better could be obtained with this iron.

#### EXPERIMENTS WITH DIFFERENT FORMS OF IRON

The experiments tabulated in Table II show the effect of using different kinds of iron, including precipitated iron oxide, which is the finest form obtainable. The iron oxide was prepared by dissolving iron sulphate and precipitating this with a solution of soda ash. The precipitate was washed free from sulphate, dried and ground a few hours with carbon in a ball mill. Soda ash was then added and the grinding continued half an hour.

The important result of small-scale experiments was that the best conversion with iron flour was about 60 per cent, with iron scale as high as 76 per cent was obtained, both at the expense of very long milling, and with precipitated iron oxide (which was of course reduced to finely divided iron in the furnace) 90 per cent conversion was reached. Coke containing 10 per cent ash gave low conversion (No. 32).

Before it was found that mechanically strong briquets could be made without a binder, sodium aluminate (No. 28) and anthracite ashes (No. 29) were tried as binders. The ashes had very little binding quality, and both were harmful. Gas carbon (No. 54), graphite (No. 71) and charcoal (No. 73) were all tried and gave excellent results when used with precipitated iron oxide. A final lot of briquets made from charcoal for the purpose of testing the product for leaching purposes gave the

TABLE II. EXPERIMENTS WITH DIFFERENT FORMS OF IRON  
(Duration, 1 hour)

No.	Sample	Per Cent of Iron	Form of Carbon	Soda Ash (per Cent)	Hours Grinding	Temp. (Deg. C.)	Ave. Content of Cyanide (In per Cent)	Per Cent Conversion	Remarks
4	Iron oxalate	23.0	Lamp-black	27.0	...	1,035 to 1,060	18.0	73.0	.....
12	Iron oxalate	23.0	Lamp-black	27.0	...	950	13.3	76.8	.....
14	Iron oxide (e.p.)	20.0	Petroleum coke	...	...	1,050	16.5	80	.....
23	Iron scale	21.3	Petroleum coke	30.6	42	1,050 to 955	15.0	76.5	.....
25	Iron scale	21.3	Petroleum coke	30.6	42	1,040 to 880	18.1	73	.....
26	Iron scale	21.3	Petroleum coke	30.6	42	1,040 to 890	15.8	72.1	.....
28	Iron scale	21.3	Petroleum coke	32	24	950 to 1,040	18.6	60.0	5% $\text{NaAlO}_2$ contained as binder
29	Iron scale	21.3	Petroleum coke	30.6	42	1,060 to 870	14.2	61.5	5% anthracite ashes as binder
32	Iron scale	20.1	Coke with 10% ash	31.0	41	1,040 to 990	5.6	24.5	.....
34	Precipitated iron oxide	21.3	Petroleum coke	32.6	7.5	1,040 to 880	16.3	79.0	45 min. duration.
50	Precipitated iron oxide	21.8	Petroleum coke	24.8	...	995 to 855	25.2	85.0	35 min.
55	Precipitated iron oxide	24.0	Petroleum coke	25.0	...	1,020 to 930	19.2	90.0	40 min.
70	Precipitated iron oxide	24.0	Petroleum coke	29.0	...	1,040 to 900	32.1	84.2	74 min.
71	Precipitated iron oxide	22.0	Graphite	29.0	...	950 to 1,040	20.6	59.8	96 min.
73	Precipitated iron oxide	20.2	Charcoal	28.2	...	1,040 to 940	35.1	87.5	72 min.

following analysis: Sodium cyanide 34.5 per cent, conversion 92.5 per cent, iron 41.9 per cent. These briquets were more than sufficiently hard.

In heating a mass of properly prepared briquets for

\*Lundell and Bridgman, *J. Ind. Eng. Chem.*, vol. 6, p. 554 (1914).



would evidently not be possible to operate in this way for production purposes.

In experiment 62 the bottom happened to be hotter than any other part of the furnace. This must have been due to some unevenness in the charging; perhaps there was a smaller proportion of gas carbon at the bottom than elsewhere.

These experiments showed that a better heat insulation in the furnace walls would be necessary. The magnesia inner lining should be retained on account of its basic properties, but a thin layer of this should be surrounded with the best heat insulator obtainable. Unfortunately a magnesia pipe of the proper size could not be obtained. An ordinary fireclay pipe was tried surrounded with a special infusorial earth. It was found that this material was not perfectly dry and when used as a lining moisture continued to come off for hours. In order to save time it was then thoroughly dried in a reverberatory furnace, and tried again with only gas carbon as a charge. The reverberatory furnace had eliminated the moisture, and there was very good temperature distribution from the center to the clay pipe, but the exit gas still showed the presence of carbon monoxide. In order to get a high enough temperature at the bottom, the resistance was increased by placing inverted Denver crucibles in piles of two or three deep on the bottom electrode. These, as well as the clay pipe lining were badly attacked by the carbon, giving the evolution of carbon monoxide mentioned. The crucibles produced the result desired, of bringing up the temperature of the bottom part of the furnace. It was found that if the furnace were tilted in a horizontal position, the bottom heated up as much as the top without the crucibles. (Experiment 96.)

The results of the experiments with this furnace show (1) that if used the "batch" method the furnace would have to be tilted on its side to get a uniform temperature throughout its length, and (2) that a lining with at least as low a thermal conductivity as infusorial earth must be used for a furnace of this diameter (8 in.), and of still lower for a larger diameter.

#### SUGGESTED ALTERATIONS IN FURNACE DESIGN

A continuous furnace might be made by imbedding two carbon electrodes in the walls of the furnace as in Fig. 2, where the feeding and discharge mechanism are left out. It is probable that there would be no difficulty on the score of different temperatures at the top and bottom, for the entire charge would pass the hottest part.

It is also possible that after warming up the furnace, cold briquets fed in at the top would be sufficiently warmed by the time they reached the electric circuit to be conducting without the admixture of gas carbon. This would require less power and avoid sifting. These were points, however, which would require extensive alterations in the furnace to verify.

It seems that simply enlarging the scale of the experiments with iron pipes has a great deal to recommend it. If steel tubes of the right dimensions were well lagged and protected from the action of the air, connected in series with a transformer, and each tube connected with a hopper and a discharge arrangement, it is not easy to see where any difficulty would come in operating.

It would be well worth while trying either or both of these furnaces on a full-size scale.

The following table gives the results of the calculation of power required per pound of cyanide.

Power required—	Kw.-Hr.
For the reaction.....	0.75
To raise	
5 lb. of briquets to 900 deg. C.....	0.60
Radiation loss (assumed the same per pound of cyanide as in the large experimental furnace, the charge requiring three hours to pass).....	0.65
For heating nitrogen.....	0.10
Total.....	2.10
Cost, at 0.5c. per kw.-hr. =	1.1c.

If an equal amount of granular carbon had to be added this would require an additional 0.86 kw.-hr. Assuming that 35 tons of briquets are to be treated a day, producing 7 tons of cyanide, and that each tube could deliver 7 charges a day, 600 ft. of 8-in. pipe would have the required capacity. A cubic foot of briquets weighs about 50 lb. Assuming these pipes to be made of the same kind of iron as the pipes used in these experiments and the walls 1 cm. thick, the resistance of the 600 ft. would be 0.047 ohm when hot. This would correspond to a current of 5,100 amp. at 240 volts.

The cost of raw materials per pound of sodium cyanide would be approximately as follows:

	Theoretical, Lb.	Actual, Lb.	Cost, Cents
Soda ash .....	1.1	1.5	4.1
Carbon .....	0.5	0.6	0.75
Cu.ft. nitrogen....	3.6	11.0	0.2
Total cost of raw materials.....			5.
Cost of power.....			1.1

Cost of power and materials..... 6.1

It is possible that the total cost would be not less than twice this, or 12c. a pound.

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#### Production of Mineral Oil in the Dutch East Indies

The following table, given in the Jan. 2, 1922, issue of *Commerce Reports*, shows the production of mineral oil in the Dutch East Indies, by districts, during the past four calendar years:

Districts	PRODUCTION OF OIL, IN METRIC TONS OF 1,000 LITERS EACH, 1917, 1918, 1919 AND 1920.			
	1917 Metric Tons	1918 Metric Tons	1919 Metric Tons	1920 Metric Tons
North Sumatra.....	175,839	194,213	176,458	194,440
North Palembang.....	82,917	121,561	148,295	138,315
South Palembang.....	222,321	204,215	197,003	203,727
Total of Sumatra.....	481,277	519,989	521,756	536,482
Semarang Residency.....	16,790	12,466	7,200	33,818
Rembang Residency.....	180,827	172,759	194,329	259,371
Soerabaya Residency....	55,104	55,952	56,986	59,260
Madura.....	94	35	140	25
Total of Java and Madura.....	252,815	241,212	258,655	352,474
Dutch North Borneo....	251,939	333,693	602,031	711,108
North Koetei.....	22	140	64	
South Koetei.....	617,301	665,733	602,278	744,119
Total Dutch Borneo...	869,262	999,426	1,372,140	1,455,227
Island of Ceram.....	2,256	3,574	7,311	21,137
Grand total for Dutch East Indies.....	1,605,610	1,764,201	2,159,862	2,365,320

Note—1 United States barrel = 159 liters.

#### Glass Industry Expanding in Australia

Three glass-manufacturing companies have been registered in Melbourne recently. These are the Victorian Glass Bottle Works Proprietary, Ltd., South Yarra, authorized capital £5,000; the Crystal Glass Manufacturing Co., of Western Australia, Ltd., authorized capital £50,000; and the Zetland Glass Bottle Works, Ltd., authorized capital £150,000.

## Electrolytic Iron a Commercial Product\*

Manufacture of Boiler Tubes of Electrolytic Iron at Grenoble, France—Briquetted Forms of Pulverized Electrolytic Iron Made Into Magnet Cores at Hawthorne, Ill.—Remarks on Leaching Iron From Sulphide Ores With Subsequent Electrolysis

BY BRADLEY STOUGHTON

Consulting Metallurgical Engineer, New York City

FOR more than 50 years attempts have been made to produce pure iron on an industrial scale by means of electrolysis, which modern metallurgy recognizes as the "tonnage production" method for metals in a pure form and which is the established process since a number of years for pure copper, gold, silver, aluminum, lead, zinc, etc. The combination of unexcelled cheapness with unexcelled utility for many purposes, possessed by *impure* iron, has diverted attention from the superior utility of the *pure* metal over pure copper, aluminum, etc., at a fraction of the price. We now know that pure iron is at least as soft and has better cold-working or drawing qualities than either pure copper or aluminum, besides having great advantages for household and machine purposes in respect of price, durability, maintenance of a bright surface, resistance to corrosion or tarnishing, to heat, etc.

### PROCESS OF THE SOCIÉTÉ "LE FER"

The Société "Le Fer," which numbers among its directors the eminent metallurgist Dr. Léon Guillet, controls the patents of Anthèlme Boucher, which were under laboratory investigation for several years prior to 1915, when the first industrial installation was made at the iron and boiler works of MM. Bouchayer and Viallet at Grenoble, France, using electricity from hydro-electric plants in the Swiss Alps.<sup>1</sup>

The electrolyte is ferrous chloride; the anode is iron in the form of cast iron; the cathode is a revolving mandrel upon which the pure iron (containing about 99.97 per cent Fe) is deposited in the form of a tube, which is annealed to eliminate the embrittling hydrogen, stripped and used as a boiler tube, either with or without drawing through a die.

The metal is so soft that no inner "ball" is used in the drawing operation. The 0.03 per cent of impurity is made up of the metalloids of the cast iron—namely, traces of carbon, silicon, sulphur and phosphorus. Hydrogen, which deposits with the metal, is completely eliminated by heat, as indicated by chemical analysis and physical properties, which will be described later. From the commercial viewpoint the Boucher process gains by avoiding the following operations in the making of a boiler tube: Purifying the pig iron; rolling and piercing the billet; annealing and roughshaping the tube. The costly items are as follows: Cast iron for anodes;<sup>2</sup> loss of about 20 per cent in slimes due to the use of a soluble anode; and the use of electricity, which

amounts to about one-quarter to one-third of a horsepower-year per ton of tubes produced.

In the matter of purity the Boucher tubes excel any other industrial product, and the process has the great advantage that a thin tube, which is the most costly to make by the prevailing boiler tube process, is the cheapest to make by the electrolytic process. M. Bouchayer says that he is able to meet all commercial competition in producing thin tubes, and he plans the construction of a second plant relatively near Grenoble, which would have double the capacity of the present plant.

### PROCESS OF THE WESTERN ELECTRIC COMPANY

The research departments of the American Telephone & Telegraph Co. and the Western Electric Co., in seeking a commercial process for the manufacture of pure iron in a pulverized form, employed the very ingenious expedient of utilizing the hardness and brittleness of electrolytic iron from which the hydrogen had not been eliminated, in order to get the material into a finely powdered form and compress it into magnet cores which would have high electrical resistance because the particles were not soft enough to crush together into a unit mass. When these operations were concluded, the compressed cores were baked to remove the hydrogen, leaving pure iron particles.

This process proved cheaper and better than reducing the iron powder by hydrogen from the oxide. A commercial electrolytic iron plant was therefore equipped at Hawthorne, Ill., with a capacity of about 2 tons of iron per day.<sup>3</sup> This method of securing pure iron proved to be relatively inexpensive and to afford a ready means of controlling the quality of the material.

The cores of the loading coils which are introduced at regular intervals to increase the inductance of a telephone circuit are now made of this material. The electrolyte is of ferrous sulphate and chloride and ammonium sulphate; the anode is mild steel; the cathode of polished sheets of steel, from which the deposited metal is stripped when it has reached a thickness of  $\frac{1}{8}$  to  $\frac{1}{4}$  in.; the current density is about 12 amp. per sq.ft.

### ELECTROLYTIC IRON DIRECT FROM ORE

The deposition of iron by electrolysis is from the electrolyte directly on to the cathode. The use of a soluble anode is only a means of keeping the electrolyte supplied with iron. Any other means of accomplishing the same result would give the same depositions, electrical efficiency, etc. For example, the circulation of the electrolyte, always maintaining it up to the desired standard of iron content, would effect the electrolytic action and avoid some disadvantageous features, such

\*Reprinted from the Jan. 5, 1922, issue of *Iron Age*. Slightly condensed.

<sup>1</sup>The process and works have been so well described and illustrated in the technical press, and especially by Guillet in *Revue de Métallurgie, Mémoires*, 1915, February, page 82, and by Jean Escard in *Le Génie Civil*, 1919, Aug. 23 and following issues, that details may be omitted here.

<sup>2</sup>Furthermore, a very impure cast iron must not be used, because some of the metalloids will migrate to the cathode.

<sup>3</sup>A brief description of the plant and process is given in the *Journal of the American Institute of Electrical Engineers*, July 1921, pp. 598, 599, 608 and 609. The magnetic and electrical properties of the material and the completed cores are described on pp. 600 to 608.

as the economic waste due to the loss in slimes with the soluble anode, the migration of impurities from anode to cathode, etc.

This is the novelty introduced by Frederick A. Eustis and Charles P. Perin in patents issued the former and developed jointly by them. This process has passed through the laboratory stage and commercial installation is under way. The solution of iron ore is the means of keeping the electrolyte enriched in iron in proportion as it is impoverished by the electrolytic deposition. The electrolyte is ferrous chloride; the anode is of some insoluble material such as graphite; the current density is 50 amp. per sq.ft. The cathode may be a revolving mandrel on which the iron is deposited in the form of a tube, or it may be in the form of a sheet, or a traveling belt from which the crumbs are removed continuously by mechanical means.

The process thus resembles the copper leaching and deposition process so successfully carried out at Ajo, Ariz., and elsewhere, and the established process of electrolytic zinc production. It faces the necessity of producing a metal which must sell in competition at a price lower than that of copper or zinc, but has the advantage of much lower price for ore and absence of some of the chemical difficulties encountered in the leaching and electrolysis of zinc. It may also be employed in localities where iron ore and a market for iron and steel exist, but where solid fuel for smelting is costly. It differs from the usual "direct process" in that it can deliver a product in finished form, ready for market, instead of a "sponge" which is commercially equivalent

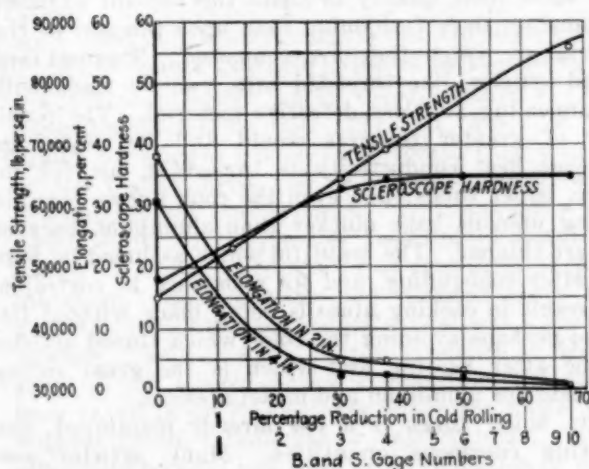


FIG. 1. CHARACTERISTIC CURVES OF ELECTROLYTIC IRON

to a poor grade of steel scrap and must be submitted to several processes before it has industrial usefulness. It differs from the electric smelting of iron in that it will produce a very pure product without the use of any flux.

Obviously, it can be applied to any iron ore capable of solution, but its cheapest raw material is the abundant sulphide ores which occur in many parts of the world and which sell at a low price, because, first, of their abundance, and second, their inapplicability to blast-furnace smelting until after a process of complete roasting. Such ores also yield their sulphur content as a byproduct, at a price which more than covers both the cost of sulphur production and the total cost of the ore itself.

The present projected application of the Eustis process is to an iron sulphide ore containing a small amount of copper, and the operations will deliver in marketable

form the iron, the sulphur and the copper in one short series of processes.

Pure iron is deposited on the cathode and the ferric chloride formed in the anode compartment is used over again for leaching, thus making the process cyclical. Sulphur is recovered as brimstone and copper is precipitated out on scrap iron. The speed of leaching depends on the fineness of pulverization of the ore, but presents no difficulties whatever after extended laboratory tests, although it is important to avoid unnecessary use of chlorine by mechanically separating such oxides as lime and magnesia before solution. Leaching is assisted by the circumstance that the reaction is

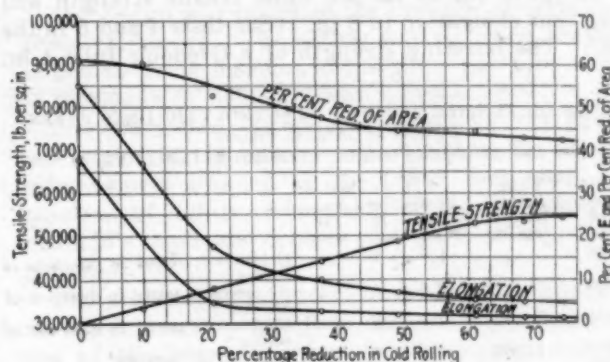


FIG. 2. CHARACTERISTIC CURVE OF ELECTROLYTIC COPPER

This curve represents the change in physical properties which accompanies cold work on the metal. The abscissas represent percentage in cold rolling.

exothermic. Counter-current extraction has resulted in delivering 97 per cent of the iron and 90 per cent of the sulphur content of the ore.

It is unique in metallurgy for one brief cycle of operations to deliver in marketable form more than 90 per cent of any ore. In the electrolytic vats the electrolyte is circulated vigorously, resulting in smooth, compact deposits being obtained; the cathode current efficiency is 90 per cent and over. With proper control no chlorine is lost, or other noxious gases given off. Each step of the process uses standard apparatus which has been developed after years of commercial operation, so that the transition from laboratory to full-scale industrial operation involves no costly experiments.

#### PURITY OF ELECTROLYTIC IRON

The only serious impurity in electrolytic iron is hydrogen, and this may be entirely removed by baking at a moderate temperature. Traces of other elements may be present by inclusion during deposition, but no great precautions are necessary to produce metal assaying 99.9 per cent and higher. Tubes made at Grenoble and analyzed in America showed 99.97 per cent Fe, and tubes made by the Eustis process assayed 99.99 per cent. It is noteworthy that it costs no more to make the very pure material than to deposit metal of inferior grade, depending upon the process employed.

#### MECHANICAL QUALITIES OF ALMOST PURE IRON

The mechanical qualities of pure iron are greatly affected by heat-treatment and cold-working; furthermore, the presence of hydrogen, due either to original deposition or to absorption at a red heat (for some persons, through inexperience, have "annealed" the metal in hydrogen gas and then tested it tensilely) destroys its strength and renders it both hard and brittle as well. The crystalline structure of the deposited

metal is fairly coarse and well defined. It is refined on appropriate annealing, and, on rolling or drawing in the cold state, it takes a beautiful fine structure and brilliant polish, which is more than ordinarily durable on exposure to the atmosphere, dampness, etc. Naturally this refining of the structure is accompanied by increase of strength.

An average of tests made by the National Tube Co. on tubes made at Grenoble, in the condition in which they were received, showed tensile strength in the direction of rolling 62,000 lb. per sq.in. and elongation of 12 per cent in 8 in.; the average of three tests of similar material, redrawn and annealed at 900 deg. C. for 20 minutes gave 39,000 lb. per sq.in. tensile strength and 30 per cent elongation in 8 in. (See tests 4 and 6 in the table.) The bursting strength of a Grenoble tube 4 in.

TABLE OF TENSILE TESTS OF ELECTROLYTIC IRON TUBES  
(Made at Grenoble, France)

(See also the physical tests in "Characteristic Curve," Fig. 1)

Ultimate Strength, Lb. per Sq.in.	Yield Point, Lb. per Sq.in.	Elongation Per Cent	Red. of Area, Per Cent	
72,600	.....	1.0	2	.. Cold-rolled; tested in direction of rolling.*
78,500	.....	8.0	4	.. As received; tested in direction of drawing.†
57,800	.....	0.5	2	.. Cold-rolled; tested in direction of rolling.*
62,000	52,000	12.0	8	50 As received; average.‡
38,300	.....	0.5	1	.. Cold-rolled; tested across direction of rolling.*
39,000	27,000	30.0	8	60 Annealed; average of three results.‡
41,800	.....	35.0	4	.. Annealed; tested in direction of drawing.†

\*Tests made at Columbia University. †Tests made by General Electric Co.  
‡Tests made by National Tube Co.

in diameter and 0.03 in. thick, reported by Escard in the *Génie Civil* article cited above, was 1,110 lb., corresponding to a fiber stress of 73,500 lb. per sq.in. It is very probable that pure iron, like very soft steel, would increase greatly in tensile strength without losing much in ductility by subjection to a double heat-treatment.

#### COLD-WORKING PROPERTIES

In *Le Génie Civil* monograph tests are described and photographs given showing the extraordinary softness and cold workability of the Grenoble tubes. Escard says it is the regular practice at Grenoble to draw five

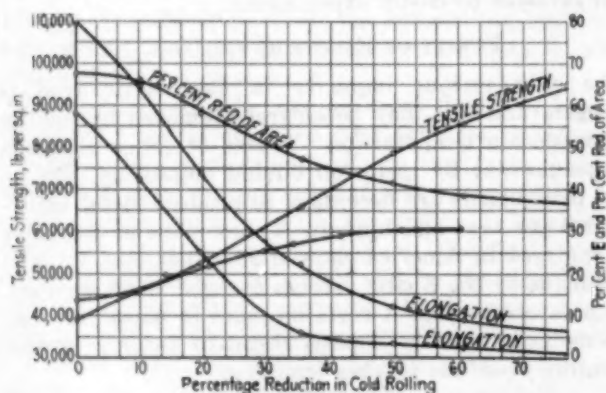


FIG. 3. CHARACTERISTIC CURVES OF TUBING METAL

times through a die without annealing, as compared with the customary practice with soft steel to anneal before each draft. This statement is corroborated by tests made in America, at the plant of the Stanford Steel Products Co., of iron made at Grenoble and iron made by the Eustis process. Tests of cold-rolling, deep stamping after cold-rolling and without annealing, cold-rolling and

beading, threading, etc., showed that the electrolytic iron would undergo work with much less frequent annealing than soft, open-hearth steel, and would endure more cold deformation without cracking than ingot iron, Toncan metal, and, in some instances, electrolytic copper.

This softness and ductility open a wide field of usefulness, because the saving in cost of annealings alone (which is an expensive item in cold-rolling work) is an important economic feature, besides the greater ease of working and lessened defective articles. Additional light on the cold-working qualities of pure iron is shown by Fig. 1, "characteristic curve," with which are compared electrolytic copper (Fig. 2) and "tubing metal" (Cu 75 per cent; Zn 25 per cent). The latter is given because its qualities so much resemble those of pure iron.

#### RESISTANCE TO CORROSION

A test made at the Massachusetts Institute of Technology by Prof. Carle R. Hayward showed that a piece of Byer's wrought-iron pipe corroded nearly twice as much, and Shelby steel tubing 2.6 times as much in the atmosphere as electrolytic iron made by the Eustis process. According to the same authority, an immersion test of 22 hours in 5 per cent sulphuric acid gave a ratio of loss of weight per unit of area:

For electrolytic iron.....	1.00
For steel.....	4.25
For wrought iron.....	18.50

#### FIELDS OF USEFULNESS

There are many articles whose value is dependent more upon their quality or upon the amount of labor expended on their fashioning than upon the cost of the material of which they are composed. Stamped and beaded articles, like threaded caps, can be made with less annealing and less defective material. The possibility of greater thinness would find its advantage wherever heat conductivity is important, as, for instance, boiler tubes; and even the cook knows that tin cooking utensils bake quicker than aluminum, because they are thinner. The beautiful polish assumed by pure iron after cold-rolling, and its resistance to corrosion, may result in cooking utensils being made without tin, and so perhaps avoiding the color which tinned articles assume after heating and which is the great selling argument for aluminum and nickel utensils.

Thin boiler tubes is a use already mentioned, and involving enormous quantities. Many articles now stamped of copper, because of its softness, could be stamped of electrolytic iron at a greatly reduced price. Where the advantage of increased resistance to corrosion is valuable, there are many uses, such as eaves troughs; boiler tubes (again); pipes and culverts; containers for water and corrosive liquids; parts of automobiles requiring to be bright, ornamental articles to be nicked and exposed to the weather, where rust soon attacks ordinary steel through its coating and mars its attractiveness; even galvanized, or tinned and painted goods would be more durable if the body of the material were of a less corrosive nature.

Add to this the economic possibility of making electrolytic iron in districts where solid fuel is now too costly for smelting, and we can visualize the commercial advantage of the new industry to localities which already use, or would use, large quantities of articles whose high price is due more to the labor expended on fashioning them than on the cost of the basic material. We are only beginning to secure the information as

to the kind and amount of such articles. Where purity alone is important, we have material like welding wire, for which a fancy price is now paid for relatively pure material. Iron for magnetic purposes has already been mentioned. It is thought that, as greater quantities of pure iron are available for research, investigation will enlarge this field. Electrical conductivity purposes should be included; and, finally, pure material as the basis for the manufacture of high grade, high priced steel for alloy steels, cutting tools, etc.

The "characteristic curves" of electrolytic iron compared with electrolytic copper shown in Figs. 1 and 2 indicate the use of this material in the form of wire for electrical purposes. It is evident that the wire can be cold-rolled so as to have far better tensile properties as transmission lines than electrolytic copper. It will be noted from the previous tests quoted that electrolytic iron has 10 to 20 per cent greater conductivity than steel. It is therefore about the equivalent of copper-clad steel; or the electrolytic iron may be copper clad, thus increasing its conductivity by another 20 per cent or so, and leaving it still not so soft and ductile as to have the objectionable stretching qualities of copper in transmission lines.

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## Legal Notes

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BY WELLINGTON GUSTIN

### Test of Unfair Competition Through Use of Some Natural Names in Business

From the United States Circuit Court of Appeals comes an interesting case (271 Fed., 395). A suit in equity for alleged unfair trade competition was begun by the Walker Bros. Co., of Boston, against W. & H. Walker, Inc., of Pennsylvania. This was not a case in which either of the parties resorted to similitude of names for unfair purposes, or of similitude of labels or markings. Both parties had adopted their natural names in their business and defendant was a much older concern. Neither knew of the existence of the other prior to the alleged unfair competition, yet each had been carrying on its business under the name Walker, without fraud, intentional or unintentional, upon each other, and without any substantial confusion or misleading of the consuming public, until the Boston Walkers discovered that the Pennsylvania Walkers were introducing their goods through jobbers and wholesale dealers.

The position of the Walkers of Boston was that under the circumstances they were entitled to the wholesale field in a particular locality, because they were first in that field under the Walker name.

On this proposition the court says such affirmance would interfere with the fundamental rights of reasonable trade competition and with reasonable and commendable purposes of trade enterprise through expansion. However, it is true that business expansion, through instrumentalities in the wholesale and jobbing fields, might be under such circumstances of bad faith, with or without involving deceptive devices, such as similar trade-marks and names, as to make the competition unfair. But none was found in this case.

In some cases of unfair competition the question depends on the purpose or on the good faith or bad faith of the dealers, while in others the question is whether

the situation in and of itself, without regard to good or bad faith, is calculated to deceive the public; but the test is always whether trade is being unfairly interfered with, and whether the public is being cheated into buying or paying for something which it is not in fact getting.

### Rights After Expiration of Patent Design

In the case of Lenox, Inc., vs. Jones, McDuffee & Stratton Corporation (271 Fed., 511), the Lenox company brought suit upon a design patent, No. 50,064, which had been issued Dec. 19, 1916, under an express term limiting it to 3½ years. The designer was Frank G. Holmes, who assigned his rights to plaintiff.

The design was intended for the face of certain high-grade chinaware. The article was put upon the market as one of great merit, and the sales ran into hundreds of thousands of dollars within a single year.

The court said the chief difficulty of the plaintiff's case was that the patent expired before the menace of infringement claimed by the Lenox company. So the question of unfair competition of the defendants with plaintiff's business became the only serious question involved.

The rights of monopoly, under patents based upon machines, instrumentalities, designs, etc., expire at the end of the term expressed in the patent, and things covered by the patent become public property—provided they are reasonably marked by the name of the manufacturer who adopts them, and are reasonably and properly designated as something made by one, other than the original patentee or producer or manufacturer, by giving the true name of the one who makes them and puts them into the trade, except perhaps in cases exactly like, or perhaps something in very close similitude of, the original in bad faith, to the end that purchasers shall not be deceived into buying a particular thing as an original when it is not.

### CASE HINGED ON MARKINGS

From this law the court said the chief question presented was whether the articles of English manufacture which Jones, McDuffee & Stratton think they may put into their trade are suitably and properly designated as another and as an English product, to the end that they shall reasonably differentiate themselves from the Lenox "Ming." The court found there were considerable differences in the design and coloring in the English and American product, the English ware being of much cheaper grade, selling for one-fifth the price of the American, and the markings on the bottom of the English wares were distinctly different, having the name of the manufacturer and the word "England."

"Patent monopoly," said the court, "was intended by the framers, in the primal sense, among other things to advance science and to encourage invention in respect to instrumentalities, to stimulate original and attractive designs in the field of art, through granting exclusive control to inventors and designers for a limited period. Yet it still remains that it is quite as true, in the broader and more important sense, that there was an intent in the interest of the general public, to the end that the public at large, after the limited monopoly had had its run, should receive the benefits of developments which the government had encouraged through giving exclusive monopoly to inventors and designers for a limited period."

Exclusive control in the Lenox patent had expired by its express terms. Therefore, if there was no wrongful

purpose, the Lenox design, except as to limited qualifications, is open to others. And the court said that if the English product, which the defendant company proposed to use, was suitably marked and designated as English product, so that purchasers would not be led to believe that they were getting the original Lenox "Ming" when in fact they were getting something else, there was no wrong.

Hence the suit against the English company was dismissed.

## Protecting Iron With Paint Against Atmospheric Corrosion

SOME experiments in the protection of iron with paint against atmospheric corrosion were described recently to the Iron and Steel Institute (British) by Dr. J. Newton Friend, Carnegie Gold Medalist. These experiments consisted in exposing, for a period of 5 years, a series of plates of steel coated with various paint mixtures, and determining their loss in weight due to corrosion.

These plates measured 2 ft. x 1 ft. x 0.03 in. thick (No. 22, B.w.g.), and were made of open-hearth steel, cold-rolled and charcoal-annealed. They were cleaned by immersion in dilute sulphuric acid, then washed and placed for a few minutes in dilute caustic soda solution to remove any traces of acid. After again washing and drying, the plates were finally polished with emery paper. After weighing and painting, the plates were suspended on a specially constructed wooden fence erected on a low bank running almost due north and south in the valley of the Severn River.

In order that the results might be as reliable as possible and relatively independent of the effects of minor variations in chemical and physical properties from which iron plates are so likely to suffer, five plates were used in each test. Unfortunately, during the absence of Dr. Friend on military service, some of the plates were blown down during gales and damaged. This accounts for the gaps in the table of results.

After 5 years' exposure to the atmosphere the plates were removed, soaked in caustic soda solution to remove the paint, washed, dried and any adherent rust gently rubbed off by scraping and polishing with emery paper.

The oils used in these experiments were:

No. 1. Pure Calcutta raw linseed oil.

No. 2. Same oil as No. 1, heated for 16 hours to a maximum temperature of 305 deg. C. No drier.

No. 3. Oil No. 1, heated for 4 hours with 0.5 per cent Cyprus umber up to 305 deg. C.

No. 4. Oil No. 1, heated for 2 hours with 1.5 per cent manganese hydroxide to 150 deg. C.

No. 5. Oil No. 1, heated for 4 hours with 1 per cent litharge to 205 deg. C.

Dr. Friend has already demonstrated the superiority of polymerized linseed or litho oils over the raw oil for the protection of iron against atmospheric corrosion. This is attributable in part to their diminished permeability toward water, but mainly to their greater stability, polymerization resulting in the saturation of the double bonds, thus rendering the oils less liable to oxidation and disintegration upon exposure.

On the other hand, an ordinary boiled oil is partially oxidized in the process, and, particularly if a drier be

present, a marked increase in the rate of setting is observed when the oil is spread as a paint film on a suitable surface. One of the main objects of the "boiling," indeed, is to increase the rate of setting. But the same catalysts which accelerate the setting or initial oxidation also accelerate the disintegration or show further oxidation upon prolonged exposure to air. Hence, in contradistinction to litho oils, ordinary boiled oils will not as a rule offer as good protection to iron as the raw oil. This is shown clearly in the results in Series A, B, C, D in the table.

Not only do two coats of paint protect iron from atmospheric corrosion more efficiently than one thinner coat, but they are even slightly more efficient than one thick coat containing the same weight of paint as the two together.

It is important to remember that this applies only to atmospheric corrosion, for Dr. Friend has shown that a precisely opposite effect is obtained by prolonged immersion of iron plates in water. The amount

TABLE I—RESULTS OF EXPOSURE TESTS  
All weights are expressed in grams. Period of exposure, 5 years.

Series	Composition of Paint by Weight	Wt. of Paint on Each Side	Loss in Wt.	Mean Loss
A	60 red lead } 40 oil No. 1 }	15	3.35	3.63
			5.95	
			3.05	
			3.50	
			2.30	
B	60 red lead } 40 oil No. 2 }	15	5.25	4.87
			5.82	
			3.55	
			7.20	
			6.62	
C	60 red lead } 40 oil No. 4 }	15	3.80	6.91
			6.58	
			7.10	
			4.30	
			6.62	
D	60 red lead } 40 oil No. 5 }	15	3.80	5.45
			6.58	
			7.10	
			4.30	
			6.62	
E	First coat: 60 Venetian red } 40 oil No. 3 } Second coat: 30 Venetian red } 70 oil No. 3 }	12	2.25	2.66
			2.48	
			3.25	
			1.35	
			1.80	
F	First coat: 30 Venetian red } 70 oil No. 3 } Second coat: 60 Venetian red } 40 oil No. 3 }	12	1.35	1.30
			1.80	
			0.75	
			2.28	
			1.45	
G	Two coats: 45 Venetian red } 55 oil No. 3 }	12 Each	2.28	2.13
			1.45	
			2.65	
			2.28	
			1.45	

of corrosion under these conditions actually increases with the number of coats or thickness of the paint.

The question now arises as to whether or not the method of mixing and applying paint to iron may not influence the results. To determine this a series of plates were given two coats of paint, viz:

Series E. One coat of 60 per cent Venetian red paint, followed by one of 30 per cent.

Series F. One coat of 30 per cent Venetian red paint, followed by one of 60 per cent.

Series G. Two coats of 45 per cent Venetian red paint.

It will be observed that the total weight of both pigment and oil on each plate in the three series is the same, but the results are strikingly different. Series F yields by far the best results, the thin coat apparently clinging tenaciously to the surface of the metal, while the outer coat, containing a high pigment and low oil percentage, protects the inner by reason of its greater resistance to permeability by moisture and to mechanical erosion.

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## Technical News of the Week

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Current Events in the Chemical, Metallurgical and Allied Industrial Fields—Legislative Developments—Activities of Government Bureaus, Technical Societies and Trade Associations

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### Dye Investigation Likely to Be Postponed as Sub-Committee Continues to Dwindle

With the announcement by Senator Reed of Missouri that it will be impossible for him to serve on the sub-committee selected to conduct the investigation of the dye situation, Senator Knute Nelson of Minnesota fears that it may be impossible to conduct the investigation at this time. Senator Borah of Idaho, another member of the sub-committee, previously had announced that he could not serve. Thus Senator Shortridge of California, chairman of the sub-committee, is the only member left of the original committee named.

Some of those who were very anxious that this investigation be conducted seem to have lost their enthusiasm since the resolution was broadened to include a probe into the practices of importers and representatives of the German dye interests. On the other hand, the domestic chemical industry appears to be more anxious than ever that the investigation proceed. It is stated that evidence has been uncovered which will reflect unfavorably upon the practices of certain textile concerns and other consumers of dyes. Since the adoption of the Frelinghuysen amendment which extended the scope of the probe to include the importers, some very active work has been done by the domestic chemical industry, with the result that enough already has been disclosed "to hang some of them," as one representative of the chemical industry put it. If this evidence can be brought out before the Senate acts on the tariff, it is expected that it will do more than any other one thing to aid the fight for an embargo.

### Licensing of Professional Engineers Subject of Live Debate in Engineering Circles

At the recent meeting of the American Engineering Council of the Federated American Engineering Societies in Washington, a lengthy discussion arose as to the sentiment of the Council regarding the licensing or registering of engineers. Prof. Donald Derickson of Louisiana was the chief advocate of the system, asserting that the experience of his state had been such as to justify the conclusion that the licensing statute had been beneficial alike to the public and the engineer. The Council finally decided to direct the appointment of a committee to make a thorough study of the question.

The Engineers' Club of Baltimore, Md., also recently considered this question and after a thorough discussion of the subject went on record as strongly opposed to any form of state legislation requiring the registration or licensing of professional engineers in Maryland. The opponents of the system, while conceding it would be an excellent thing if it were practically possible for any board to grade each engineer according to his true qualifications and ability, asserted that engineering work is more varied and diversified by far than any other profession and thus it is not to be expected that any state-appointed board could handle the proper grading of individual engineers.

### E. F. Smith Addresses Rochester Section, A.C.S.

Dr. Edgar F. Smith, president of the American Chemical Society, addressed the last meeting of the Rochester Section, A.C.S., Dec. 19 at Kodak Park. Choosing as his topic "A Glance at Early Organic Chemistry," Dr. Smith outlined the history of the science and called particular attention to the work of Americans in developing ether, chloroform, synthetic indigo and camphor.

Following this address, motion pictures showing the manufacture of motion picture film at Kodak Park were shown.

### Elaborate Program Planned for Meeting of American Ceramic Society

As previously announced, the American Ceramic Society's twenty-fourth annual convention will be held at the Hotel Statler, St. Louis, Mo., Feb. 27 to March 3 inclusive. Three days will be devoted to presentation and discussion of papers on manufacturing problems; two days of open house will be held at industrial plants and seven divisions will meet simultaneously. In addition to the smoker and banquet, exhibits of equipment will be encouraged. The general chairman of the local committee is J. L. Green, 1673 Railway Exchange Building, St. Louis, Mo.

Among the forty papers announced to date are the following:

"The Testing of Silica Brick," K. Endell, Charlottenburg, Germany.

"A New Method of Measuring the Porosity of Brick," E. W. Washburn and E. N. Bunting.

"The Products of the Calcination of Flint and Chalcedony," E. W. Washburn and Louis Navias.

"Refractories Engineering," W. E. Dornbach, Baltimore, Md.

"Comparison of Hot and Cold Modulus of Rupture for Silica Brick," E. N. McGee, Syracuse, N. Y.

"Refractories for Zinc Smelting," George C. Stone, New York City.

"Possibilities of Terra Cotta Casting," R. F. Geller.

"The Cost System as an Aid to Efficient Plant Control," D. T. Farnham.

"The Permeability and Diffusion of Gases Through Refractories," H. W. Douda, Columbus, Ohio.

A number of subjects of timely interest are being prepared for round-table discussion.

### Commonwealth Edison Co. Opens New 250,000-Hp. Plant in Chicago

The Commonwealth Edison Co. of Chicago has thrown into operation a new \$10,000,000 power plant located in South Chicago on the Calumet River near 100th St. for supplying the industrial district. When this station is eventually completed as planned, it will generate 250,000 hp. With the new plant the capacity of the plants of the Commonwealth Edison Co. now exceeds 800,000 hp. It is planned later to build another 250,000-hp. station on the shores of Lake Michigan at Waukegan with the Public Service Co. of Northern Illinois, which will fit into a scheme of electric superpower development of Wisconsin, Illinois and Indiana. The Chicago system has become the hub of a network of interconnected electric transmission lines in the upper Mississippi Valley which spreads nearly to Minneapolis on the north, southwest to the Mississippi River, and south to the coal fields of Kentucky. The development of power generation on this huge scale is indicative of the industrial growth of this section of the Middle West.

### Laboratory Tests for Molding Sand to Be Standardized

A committee, organized by the National Research Council and American Foundrymen's Association, has reached agreement on six tests which will show the properties that are most indicative of satisfactory working conditions of the sand in almost all lines of foundry practice. The "fineness" test and "cohesiveness" test should be given first consideration. Tests for permeability, water content, thermal properties and rational and chemical analyses should also be considered in a general study of molding sands. Information is now being acquired preparatory to drawing up specifications for the proper methods of making such tests.

### American Engineering Council Holds First Annual Meeting

The American Engineering Council of the Federated American Engineering Societies held its first annual meeting in Washington, D. C., on Jan. 5 and 6. A leading event of the meeting was a dinner in honor of Secretary of Commerce Hoover at which Mr. Hoover commended the Council's work for the elimination of waste in industry, declaring this to be the most fundamental of all problems with which the nation must deal. He urged the development of methods for effecting economies in manufacture, transportation and distribution and suggested that the problem of national electrification be taken up in the form of a waste survey.

The Council voted to continue support of the legislation for the relief of the U. S. Patent Office as embodied in the Lambert bill. Steps were also taken to co-operate with the Department of Commerce in the movement to prepare for cyclical industrial depressions and unemployment by resort to public works projects. An unqualified indorsement of an embargo on dyes was voted by the Council.

Officers for the year are as follows: president, Dean Mortimer E. Cooley, of the University of Michigan; vice-presidents, D. S. Kimball of Cornell University and J. Parke Channing of New York; treasurer, W. W. Varney of New York; executive secretary, L. W. Wallace.

### Steady Business Improvement Indicated by Increased Production in Industries

**Ceramic.** The five general ware potteries at Sebring, Ohio, are now working at practically full time and expect to maintain production at this status for at least 6 months to come. The different plants are the Sebring China Co., Limoges China Co., Royal China Co., Worcester China Co. and the Saxon China Co.

The Crip Pressed Brick Co., Ennis, Tex., has resumed production at its plant under an operating schedule of about 20,000 bricks per day.

The Haws Refractories Co., Hawstone, near Lewistown, Pa., has resumed operations at its plant after a shutdown for a number of months. Production will be maintained on a basis of 50 per cent for the present.

The majority of potteries at Wellsville, Steubenville and East Liverpool, Ohio, devoted to the production of general ware, have resumed production on a full-time schedule, following a shutdown through the holiday week for inventory and other purposes.

**Chemical.** The National Aniline & Chemical Co., Wilmington, Del., has added a number of permanent workers to the operating force at its local plant.

**Rubber.** The Goodyear Rubber Co. is planning for the early resumption of operations at its local plant, following a 2 weeks' shutdown. A wage reduction from 10 to 25 per cent for male operatives at the plant has been announced.

The Goodyear Tire & Rubber Co., Akron, Ohio, has added about 1,000 employees to the working force at its local mills since the middle of December. It is expected to increase the number of present workers soon.

**Glass.** Practically all of the glass plants in the Wheeling, W. Va., district are now in operation, with production varying from 80 per cent to full capacity.

Glass factory at Sisterville, W. Va., will resume operations Feb. 1 after being idle over a year.

**Oil.** The Standard Oil Co. has increased the working force at its Bayway refinery, Elizabeth, N. J., to more than 4,100 men, the largest number which has been employed at any one time since last May. The plant is operating on full time.

**Paper.** The New York & Pennsylvania Co., Johnsonburg, Pa., operating a local paper mill, has increased production to close to capacity.

The Charles Boldt Paper Co., New Iberia, La., manufacturer of paper products, has placed its recently completed mill in operation.

The Trinity Paper Mills, Commerce, Tex., manufacturer of paper pulp from cotton linters, has placed its new mill in operation.

**Iron and Steel.** The Tennessee Coal, Iron & Railroad Co.

and the American Steel & Wire Co., both subsidiary to the United States Steel Corp., are operating their plants in the Birmingham, Ala., district in excess of 60 per cent of normal.

The E. & G. Brooke Iron Co., Birdsboro, Pa., has blown in its local furnace, which has been idle for about 10 months past. Employment will be given to about 130 men.

The Reading Iron Co., Reading, Pa., has resumed operations at its Oley St. mills on a full-time schedule. Plans are under way to place the puddle mills on Ninth St. in service at an early date.

The Allegheny Steel Co., Brackenridge, Pa., has resumed operations at its plant after a shutdown of a number of weeks. A group of ten sheet mills at the works, now idle, will be placed in service before the close of the month.

The Altoona Iron Co., Altoona, Pa., has resumed production at its local plant after being idle through the greater part of the past year.

The Trumbull Cliffs Furnace Co., Warren, Ohio, will soon blow in its local blast furnace, rated at 600 tons. The plant has been completed at a cost said to be about \$3,000,000, and operations have been held in abeyance for some time past owing to conditions.

### Outlawing of Chemical Warfare Not Likely to Stop Gas Research by U. S.

Influence on the part of friends of the capital naval ship is said in Washington to have been an important factor in the decision of the Arms Conference to outlaw chemical warfare. When the Chemical Warfare Service demonstrated last summer, in the tests in the lower Chesapeake Bay, that gas could be used effectively against ships, it was not realized, some point out, that it was paving the way for its own destruction. From the date of those tests there has been an increasing animosity to gas in naval circles. This is not confined to the United States, but it applies equally well to many of the advocates of the superbattleship in other countries.

The idea of outlawing chemical warfare had its inception and its chief impetus in the advisory committee to the American delegation. The advisory committee was a sort of afterthought of the conference idea. The committee was selected at the last minute and no advance notice was given those who were appointed to serve. Most of its members took the appointment as complimentary, but a few of those designated took the matter seriously and insisted on advising, much to the embarrassment of certain officials. Senator Sutherland, chairman of the advisory committee, Secretary of Commerce Hoover and John M. Parker, Governor of Louisiana, outstanding members of the committee, are known to have been of the opinion that it would be just as practicable to agree to outlaw war itself. Since Secretary Hoover and Governor Parker are busy men, they devoted very little time to the affairs of the advisory committee. Certain members of the committee, sensing the approval which would follow this course from that portion of the public which had not looked into the subject deep enough to know that chemical warfare is the most humane, efficient and least expensive of all the modern weapons, pressed their report with utmost vigor, it is declared. There has been no explanation as to how General Pershing was induced to reverse himself on the subject. His testimony before the House Committee on Military Affairs just prior to the establishment of chemical warfare as a separate service of the army was an indorsement of a positive character.

Representatives in Washington of the chemical industry point out that the conference would not have thought of concluding an agreement as to the reduction of naval armament unless England, the chief naval power, were to be a party to it. There was no hesitation, however, in attempting chemical disarmament by decree, and Germany, still armed to the teeth chemically, was in nowise considered.

Insufficient time has elapsed to allow any arrangement of details, but since England made the expressed reservation that it would be necessary to keep abreast with chemical development, to guard against the use of gas by an outlaw nation, it is assumed that the United States will not abandon the research work on gas which it now has well under way.

### Catalysis and Photomicrography Subjects at New Jersey Chemical Society

Large attendance marked the regular monthly meeting of the New Jersey Chemical Society on Jan. 9, 1922, in Newark. N. J. H. S. Taylor, of Princeton, spoke on "Auto-Catalysis," describing several reactions in which one of the products of the reaction apparently acts as a catalytic agent. Dr. Taylor described some recent experiments on the reduction of cupric oxide by hydrogen and on the efflorescence of cadmium sulphate crystals in support of his contention that in this type of reaction it is only at an interface, where a molecule of the substance is in contact with a molecule of one of the products of its decomposition, that the reaction proceeds.

Charles P. Titus, consulting microscopist, New York, gave a profusely illustrated talk on fabrics, outlining methods of manufacture and showing photomicrographs of numerous textiles.

### New York Section of A.C.S. Hears Papers on Glues and Gelatins

The subject at the regular monthly meeting of the New York Section of the American Chemical Society on Jan. 6, 1922, was "Glue and Gelatin." The speakers were R. H. Bogue, Mellon Institute, S. E. Shepherd, Eastman Kodak Co., and E. T. Oakes, National Biscuit Co. Dr. Bogue's paper dealt with the classification of glues and gelatins and is reported in more detail on page 123 of this issue. Dr. Shepherd's paper discussed photographic gelatin, describing the protective action of the gelatin in delaying precipitation, its important effect on the coating operation due to its varying viscosity and the sensitizing or desensitizing effect of gelatin on the emulsion due to the presence of small quantities of metallic impurities, sulphides, grease and organic reducing agents. The talk was illustrated with slides showing curves, photomicrographs of emulsion grains and photographs of instruments used in the Eastman laboratory for determining the setting point, jelly strength and swelling of gelatin.

### Potash Producers Hopeful for Adoption of Five-Year Protective Duty

Sufficient sympathy for the domestic potash industry has been manifested by members of the Senate Finance Committee to lead to the belief that agricultural potash will not be returned to the free list. The chances are thought to favor the adoption of the rates contained in the House bill which prescribe a duty of 2½c. per lb. on actual potash for the first 2 years; 2c. per lb. for the third year; 1½c. per lb. for the fourth year; 1c. per lb. for the fifth year, agricultural potash thereafter to be on the free list.

The opposition to this duty came mainly from H. A. Huston, American representative of the German potash syndicate, and from the National Fertilizer Association, represented by S. D. Crenshaw, vice-president of the Virginia-Carolina Chemical Co.

Mr. Huston was frank in his admission that he had been connected with the German potash syndicate for 19 years. He declared that the syndicate had been much maligned and that it is not a monopoly even in Germany. He emphasized the fact that the German law prohibits, under heavy automatic penalties, the sale of potash for export at less than the price offered for potash for distribution within Germany. He argued that it would be to the great economic advantage of the United States to use many times the amount of potash now consumed.

Mr. Crenshaw stated that American producers, in spite of the monopoly given them by the war, had never produced more than 54,000 tons of actual potash in any one year, and that there is no reason to expect that they can produce the normal American requirements at present prices, plus the proposed tariff. He also stated that certain forms of potash much used and desired in the United States cannot be produced in this country. Another difficulty facing American producers is that freight rates alone are nearly as much as the cost of foreign potash delivered at American ports.

Wilbur LaRoe, an attorney, appeared for the United States

Potash Producers' Association. He cited the Federal Trade Commission as authority for statements that the Virginia-Carolina Chemical Co. is financially interested in certain German potash enterprises and that it has important holdings in the German potash mines. He declared that the fertilizer interests are leaving the impression, in stating that they have contracted in Germany for only 75 per cent of their requirements, that the remaining 25 per cent may be purchased of American producers. He declared that this is not a fact and that within the last few weeks contracts have been made with Alsatian producers for the remaining 25 per cent of the requirements of the thirty-four companies which entered into the German contract. It was brought out in the hearing that these thirty-four manufacturers produce at least 60 per cent of the country's fertilizer output.

Mr. LaRoe also took exception to the statement by the representative of the fertilizer manufacturers relative to prohibitory freight rates, mentioning the practicability of shipment by water and the promising potash fields in New Jersey as a source of supply for Eastern markets. The domestic supply of potash, he told the committee, is sufficient to meet domestic needs for an indefinite time. The reserve at Searles Lake alone amounts to 20,000,000 tons, he said. Already the solar method of evaporation is being used there with great success and by extending it and providing for increased efficiencies, Mr. LaRoe predicted that the United States within the 5-year period could produce potash at a less cost than can Germany. While all the American plants are closed at present, Mr. LaRoe stated that they have an annual capacity of 100,000 tons and will reopen if the duty is allowed. He estimates American requirements at 240,000 tons. Statements were presented from the State Chemists of the more important fertilizer using states to sustain his contention that California potash is now free of borax. The duty requested, it was stated, will give the federal treasury \$10,000,000 annually during the first 2 years. Mr. LaRoe declared that domestic producers are ready to start up their plants if they can be assured of receiving as much as \$1.10 for their output.

### Short Course in Ceramic Engineering at Illinois University

As previously announced, the short course in ceramic engineering at Illinois University will be conducted this year from Jan. 23 to Feb. 4. This course, as is well known to members of the American Ceramic Society, is designed to meet the requirements of practical men. It deals with the principles underlying the work of managers, superintendents, foremen, burners and others who may be concerned with the manufacture of ceramic products. Those companies who have sent their employees in previous years have been amply repaid for the time and money expended.

The courses this year will be very much on the same basis as in last year's program with some different lecturers and the addition of lectures in business law, boiler water and glass technology. Prof. Charles F. Binns, formerly secretary of the American Ceramic Society, will deliver the lectures on glazes.

### National Association of Cost Accountants Conducts Membership Drive

The National Association of Cost Accountants has recently begun a drive for 400 new members by March 1. This organization is national in scope and has members in practically every state in the Union in addition to some in Canada, Mexico and Europe.

There are local chapters in most of the principal cities of the United States. These chapters meet monthly to hear various messages by reputable cost authorities on cost and accounting problems. These local chapters are the clearing houses where cost data and plans are exchanged by representative cost men and accountants.

All those interested in cost accounting are invited to investigate the merits of the organization with a view to becoming active members. S. C. McLeod, 130 West 42nd St., New York City, is the national secretary and business agent.

### Ford Muscle Shoals Offer to Be Submitted to Congress by Secretary of War

Secretary of War Weeks, after a conference on Jan. 13, 1922, among Henry Ford, Secretary Hoover and himself, announced that the Ford offer for the Muscle Shoals plant, in the form of a contract, would be transmitted to Congress for action. He declined to make public the nature of his comments on the proposal.

The National Fertilizer Association has undertaken the publication of an analysis of the Ford offer and a survey of the situation surrounding the project, under the caption of "Truth About Muscle Shoals." It is stated therein that Mr. Ford proposes to make two kinds of payments—interest and amortization. The interest payments are a partial reimbursement to the government for the interest which the taxpayers must pay on the money invested in the water power and amount to a total of \$161,040,000 over the 100 years' lease. The government, however, must pay interest on \$57,000,000 new money invested, which at 4 per cent would amount to \$2,280,000 per year. As will readily be seen, this creates a deficit of \$600,000 or more every year.

### C. W. Goodale Honored for Safety and Welfare Work by Mining and Metallurgical Society

Charles W. Goodale, of Butte, Mont., was awarded the gold medal of the Mining and Metallurgical Society of America at its annual meeting, Jan. 10, for conspicuous services in safety and welfare work. In 1898 Mr. Goodale was appointed general manager of the Boston & Montana Consolidated Copper & Silver Mining Co., operating the richest copper mines in Butte and a large smelter at Great Falls, about 200 miles northeast, a position he filled with great success up to the time of the absorption of that company by the Anaconda Copper Mining Co. Since that time he has been chairman of the Bureau of Safety for all the Montana operations. Those same qualities which have always brought him the affectionate regard of his numberless acquaintances in mining and metallurgical circles have enabled him to enlist that sincere co-operation of all the foremen and workmen so necessary for the success of safety and welfare measures.

### Summary of Newly Organized Chemical Firms

During the month of December a total of twenty-six companies was organized to manufacture chemicals, dyes, drugs and affiliated products, with individual capitalization of \$50,000 or more. The total indicated capital aggregates \$3,595,000. This compares with the formation of thirty-five companies in November, with total authorized capitalization of \$6,300,000.

The total for the year 1921 shows an indicated capitalization for new companies organized of \$108,410,900, as compared with a capital of \$487,148,000 for new concerns in the industry formed in 1920.

### Business Paper Editors to Meet

The National Conference of Business Paper Editors will hold a meeting in Washington, D. C., on Jan. 23. After luncheon, the afternoon will be devoted to a conference with the Chamber of Commerce of the U. S., at which will be discussed the railroad situation, tariff legislation, soldier bonus and the hardwood decision of the Supreme Court. The program of the day also includes the regular dinner with Secretary of Commerce Hoover, at which problems of interest will be discussed.

### American Ceramic Society Moves Headquarters

Official announcement has been made that the headquarters of the American Ceramic Society have now been transferred from Alfred University, Alfred, N. Y., to Lord Hall, Ohio State University, Columbus, Ohio. Organizing Secretary Ross V. Purdy has automatically, with the coming of the new year, been made general secretary of the society, and his headquarters are at the above address. Charles F. Binns, who has for many years served the society faithfully and well, retired from active participation in the work.

## Personal

Dr. CLARENCE W. BALKE, chief metallurgist of the Fansteel Products Co., North Chicago, recently spoke before the American Institute of Mining and Metallurgical Engineers at the rooms of the Western Society of Engineers, Chicago, on "The Story of Tungsten."

S. M. BARNET has been elected president of the Barnet Leather Co., New York, succeeding his father, the late Morris S. Barnet. SIGMUND ROTHSCHILD was elected vice-president of the company.

C. A. BIGELOW, formerly general manager of the Aetna Explosives Co., became assistant general manager of the Hercules Powder Co. on Jan. 1, in charge of the high explosives division. On the same date L. N. BENT became assistant general manager in charge of naval stores, fulminate and caps, and nitro cotton divisions.

R. A. BULL, a consulting engineer of Sewickley, Pa., has moved his headquarters to Spondly Building, 638 Diversey Parkway, Chicago, Ill.

O. S. DELANEY, E. I. du Pont de Nemours & Co., Wilmington, Del., gave an interesting address on the subject of the manufacture of explosives at a recent meeting of the Olympia Chemical Club, Tacoma, Wash.

ROBERT W. HILTON, vice-president of the Ault & Wyborg Co., Cincinnati, Ohio, has announced his withdrawal from the company after 25 years of service. Mr. Hilton started with the company as a chemist and was in charge of the laboratory for 6 years, after which, for 9 years, he was superintendent of the company's plants, and for the last 10 years has been in charge of the development and manufacture of products. After a short vacation he will enter business for himself.

F. KNIFFEN has resigned as production manager of the cellulose products manufacturing department of E. I. du Pont de Nemours & Co. He will continue to serve that department in an advisory capacity.

Dr. S. K. LOY, chief chemist of the Standard Oil Co.'s (formerly the Midwest Refining Co.) refinery at Casper, Wyo., has been appointed consulting chemist of the Bureau of Mines in connection with oil-shale work.

THOMAS O. MARVIN has been designated by President Harding to become chairman of the United States Tariff Commission, succeeding Thomas Walker Page, who recently resigned. Commissioner WILLIAM S. CULBERTSON has been named vice-chairman.

RALPH H. MCKEE spoke before the Franklin Institute on Jan. 12, on "Gasoline From Oil Shale."

J. V. MOWE, general sales manager of the Kelly-Springfield Tire Co., Akron, Ohio, has been elected a vice-president of the company.

G. N. NORMAN, chemical director, and R. S. MCKINNEY, purchasing agent, for the Hercules Powder Co., expect to sail for Europe on Feb. 7. They will be abroad for about 3 months and will visit the principal continental countries.

C. OLIN NORTH, C. W. BEDFORD, R. C. HARTONG and C. N. HAND, all formerly connected with the development department of the Goodyear Tire & Rubber Co., have left that organization and incorporated the Rubber Service Laboratories Co. Mr. Bedford is the present chairman of the Rubber Division of the American Chemical Society.

A. L. PITMAN has been appointed assistant director of the Bangor station of the Massachusetts Institute of Technology's School of Chemical Engineering Practice.

N. P. ROOP, vice-president of the Hercules Powder Co., expects to make a business trip to Chile in the near future.

C. J. SNYDER has accepted a position as technical director of the Newman Ice Cream Co. of York, Pa. He was formerly in the chemical department of E. I. du Pont de Nemours & Co. at Parlin, N. J.

HERBERT TALLEY will leave the service of the Hercules Powder Co. on Feb. 1 to go with the U. S. Powder Co.

## Market Conditions

### IN CHEMICAL, METALLURGICAL AND ALLIED INDUSTRIES

A Survey of the Economic and Commercial Factors That Influence Trade in Chemicals and Related Commodities—Prevailing Prices and Market Letters From Principal Industrial Centers

#### The Uneven Fall in the Prices of Basic Commodities

One of the conspicuous obstacles in the path toward better times in business is the maladjustment in the wholesale prices of the principal domestic commodities. The general process of deflation appears to have run an uneven course, so that there exists at the present time an unusual disparity between the great groups of basic materials. The spread between the prices of farm products and other primary materials, on the one hand, and the prices of manufactured goods, labor and transportation, on the other is an obstruction to progress. Substantial revival of business cannot be effected as long as such unbalanced relations continue, and it therefore behooves business to study these fundamental conditions in order that means may be provided for their correction.

#### INEQUALITY IN RECESSION FROM WAR-TIME PEAKS

Babson's analysis of 78 leading articles of commerce indicates that 39 are from 50 to 100 per cent and 18 from 2 to 25 per cent above the pre-war level. On the other hand, 21 are from 0 to 82 per cent under the 1904-1913 average. This maladjustment of prices is further shown in the price indexes of the U. S. Bureau of Labor Statistics, which are shown in the accompanying table. From the 1920 maximum to the figure reported for November, 1921, these groups have shown the following percentage decreases: farm products 53.7, metals and metal products 39.0, foods 50.5, chemicals and drugs 27.0, fuel and lighting 34.5, and building materials 42.2.

#### THE COLLAPSE OF AGRICULTURAL PRICES

Almost at the bottom of the whole situation is the severe agricultural depression. The farmers produced a bumper crop during 1921, but according to official estimates of the government, their produce had a market value eight billion dollars less than the value of the crop of 1919 and three and a half billion less than in 1920.

The farmer has been forced to shoulder tremendous losses, for practically every farm product is selling for less than the actual cost of production. Furthermore, his purchasing power has been reduced correspondingly and this has necessarily had its effect on practically every branch of industry. It has been estimated by reliable authorities that the farmer's dollar purchases less goods now than it has at any time during the past 30 years.

#### CHEMICAL AND METALLURGICAL PRICES

Metals and metal products have had the next most conspicuous decline of prices. In the index numbers of the Bureau of Labor Statistics this group stands at 119 for

November, 1921, in comparison with 114 for farm products and 149 for all commodities. This represents a fall of practically 40 per cent from the peak reached in 1920. Practically every non-ferrous metal is selling at prices which are equal to or lower than the pre-war level.

Chemicals and drugs, according to the Labor Department statistics, are at a somewhat higher level, although still not greatly above the average for all commodities. It is significant to note that the chemical group reached a low of 161 in August of this year and in the three succeeding months for which figures are presented has shown a very slight increase.

The disparity between this figure for chemicals and drugs and the CHEM. & MET. Weighted Index of Chemical Prices perhaps needs some explanation. It should be understood at the outset, however, that these index numbers are obtained by entirely different methods. Although both are based on a somewhat similar selection of commodities, the

INDEX NUMBERS OF DOMESTIC WHOLESALE PRICES  
(Compiled by U. S. Bureau of Labor Statistics)

1913 average = 100

Month	Farm Products	Food, Etc.	Fuel and Lighting	Lumber and Building Materials	Metals and Metal Products	Chemicals and Drugs	All Commodities
1913 (average)...	100	100	100	100	100	100	100
1914 (average)...	103	103	96	97	87	101	100
1915 (average)...	105	104	93	94	97	114	101
1916 (average)...	122	126	119	101	148	159	124
1917 (average)...	189	176	175	124	208	198	176
1918 (average)...	220	189	163	151	181	221	196
1919 (average)...	234	210	173	192	161	179	212
1920 (average)...	218	239	238	308	186	210	243
1920:							
July.....	236	268	252	333	191	217	262
August.....	222	235	268	328	193	216	250
September.....	210	223	284	318	192	222	242
October.....	182	204	282	313	184	216	225
November.....	165	195	258	274	170	207	207
December.....	144	172	236	266	157	188	189
1921:							
January.....	136	162	228	239	152	182	177
February.....	129	150	218	221	146	178	167
March.....	125	150	207	208	139	171	162
April.....	115	141	199	203	138	168	154
May.....	117	133	194	202	138	166	151
June.....	113	132	187	202	132	166	148
July.....	115	134	184	200	125	163	148
August.....	118	152	182	198	120	161	152
September.....	122	146	178	193	120	162	152
October.....	119	142	182	192	121	162	150
November.....	114	142	186	197	119	162	149

Bureau of Labor statistics includes among its eighteen items such articles as quinine and opium. Although these may be regarded as indicative of the trend of the drug market, they are nevertheless subject to extreme fluctuations and at the present time demand unusually high prices. As explained in our issue of Jan. 11, the weighted index compiled by this magazine is based largely on such materials as the heavy chemicals and other similar products of quantity output and demand.

#### Solving Some Problems of Unemployment

A plan to take care of the families of employees out of work or on part time has recently been instigated at Lynn, Mass., plant of the General Electric Co.

All workers, including wage and salary earners, submit to a 1 per cent reduction in pay, which is impounded into a fund to be used among the unemployed. This is, however, only a temporary arrangement, since the company has not approved any general plans for unemployment insurance.

#### CHEMICAL & METALLURGICAL ENGINEERING'S WEIGHTED INDEX OF CHEMICAL PRICES

Base = 100 for the year July 1, 1913, to June 30, 1914

This week .....	143.75
Last week .....	144.49
January, 1921 .....	181
January, 1920 .....	242
April, 1918 .....	286

The very slight drop in the index number during the current week was caused principally by the lower prices for soda ash, caustic soda, bleaching powder and methanol. Slight increases in the prices for aniline oil, formaldehyde, glycerine and linseed oil failed to retard this movement.

### To Market Copper Shingles

The Anaconda Copper Mining Co. expects to use more than 30,000,000 lb. of copper this year in the manufacture of copper shingles. Although the initial cost of the new product is about twice that of the ordinary wooden shingle, has the advantages of durability and light weight. The shingles are supplied in natural copper finish and also in seven shades ranging from green to russet brown.

### Unemployment During December

Unemployment increased by 4.7 per cent during December, according to the monthly survey of the U. S. Employment Service. The survey covered 1,428 firms located in the sixty-five principal industrial centers of the country. These concerns were employing 1,493,107 workers on Dec. 31.

Increased employment is shown in textiles, iron and steel, lumber, leather, paper and printing and metals and metal products other than iron and steel. The decreases were mainly in the food industries; liquors and beverages; chemicals; stone, clay and glass products; tobacco manufacture; vehicles for land transportation, and railroad repair shops.

### German Export Trade During November

A slight decrease in the volume of German exports for the month of November as compared with the previous month has been reported from Berlin by Commercial Attaché C. E. Herring. Percentage decreases as well as increases in the volume of exports for the principal groups of commodities are shown in the following table:

Commodity	Decrease Per Cent	Commodity	Increase Per Cent
Heavy chemicals	12.0	Leather	2.0
Dyes	3.0	Leather goods	14.7
Cotton manufactures	5.4	Rubber goods	5.8
Wool manufactures	13.8	Paper, pulp and manufac- tures thereof	24.6
Glass and glassware	7.3	Pottery	1.7
Iron and steel manufactures	4.8	Machinery	5.0
thereof	12.0	Electrotechnical products	19.6
Zinc and zinc products			

The total imports into Germany decreased more than the exports, with the result that November shows a greatly diminished trade balance by volume.

### Three Years' Export Trade in Dyes

Statistics recently released by the Department of Commerce show rather vividly the decline in the value of our exports of dyes and dyestuffs. The commodities shown in the government's classification fell from a total of \$30,410,198 for the first 11 months of 1920 to \$6,465,665 for the same period of 1921.

The figures for the exports to principal countries show some rather significant changes. The most striking, perhaps, is the tremendous decrease in our dye exports to China. From over \$5,500,000 for January-November, 1920, they fell to about \$750,000 during 1921. Japan was practically on a par with China in the former year, but in 1921, although her exports were cut in half, she became by far the most important customer for American dyes.

#### EXPORTS OF DYES AND DYESTUFFS, JANUARY TO NOVEMBER, 1919, 1920 AND 1921.

Dyes and dyestuffs—	Total Exports by Classes Eleven Months Ended		
	Nov. 30, 1919	Nov. 30, 1920	Nov. 30, 1921
Aniline dyes	\$9,396,615	\$20,662,310	\$4,812,122
Logwood extract	1,299,023	2,529,192	545,060
All other	4,654,202	7,218,696	1,108,483
Total dyes and dyestuffs	\$15,349,840	\$30,410,198	\$6,465,665

Total Exports by Principal Countries			
Exported to—			
Belgium			\$99,357
France	\$928,837	\$1,728,653	141,484
Italy	382,074	1,233,286	58,861
Spain	553,995	893,730	45,951
United Kingdom	1,063,760	2,955,491	238,691
Canada	1,934,294	2,620,800	971,513
Mexico	624,578	1,085,908	275,561
Cuba			56,961
Argentina	583,761	970,296	177,677
Brazil	1,035,283	934,821	159,510
Chile	165,321	173,521	25,265
Peru	165,731	210,440	34,145
China	2,038,937	5,566,095	759,946
British India	1,442,521	3,283,676	699,340
Dutch East Indies	149,680	25,136	3,277
Hongkong	284,964	724,541	39,915
Japan	2,758,934	5,454,377	2,111,287
Australia	205,323	245,045	216,435
Other countries	1,031,847	2,304,382	335,489

### The New York Market

NEW YORK, Jan. 16, 1922.

Business in the chemical market during the past week was not of large proportions. The industry still shows the influence of the inventory period, but there are some signs of improvement. A tendency still exists to shade prices on some commodities to stimulate trading. Among the most important developments reported was a decline in the prices of caustic soda and soda ash for forward shipments and also an easier spot market for both products. Leading producers are making a great effort to get real business this year and believe that attractive prices are the only means. Numerous inquiries for caustic soda from the Orient have reached the market and a fair volume of business has been placed at slight concessions. *Silicate of soda* has been reduced by leading makers.

There has been no change recorded in the chlorate market in spite of the large importation from Germany. Commercial white powdered *arsenic* is considerably higher and in some first-hand quarters it was stated that sales as high as 8c. per lb. have been made. Imported material was quoted at \$6.75 per 100 lb. Spot resale *arsenic* was held at 7@7½c. per lb. for limited quantities only. Imported *prussiate of soda* has reached new high levels and only a few odd lots were obtainable in the open market. Sales of spot material were reported at 17½c. per lb. for imported. January shipment is held firm at 17c. per lb., with relatively little obtainable. *Bichromate of potash* is slightly lower at 10½c. per lb. Buyers are not taking much interest in this item at present. Imported white granular *salammoniac* is easier, with shipment material offered at 6½c. per lb. *Caustic potash* continues to show a strong tendency both on spot and forward shipment. Resale stocks are gradually diminishing and while it is still possible to do 6c. per lb. for the 82-92 per cent imported, 6½c. was asked in leading quarters. Export sales of solid *caustic soda* were reported at \$3.60@3.70 per 100 lb. Goods ex-store were quoted at 3½c. per lb. Producers quote contracts at \$2.65 per 100 lb. f.o.b. works, basis 60 per cent, in carload quantities. *Soda ash* in single bags is moving quietly at \$1.75@1.80 per 100 lb. Sales of *soda ash* in barrels were reported at \$2.10@2.15. At the works, producers are accepting contract business at \$1.35 per 100 lb., basis 48 per cent. *Glycerine, c.p.*, was advanced ½c. per lb. on spot and quotations at the end of the week ranged from 16½@17c. per lb. Demand has been much better in this item since New Year's. *Prussiate of potash* continued in its firm position and supplies have practically disappeared in second hands. Manufacturers stated that limited supplies were available at 24½@25c. per lb. The red variety was also available in limited quantities at prices ranging from 29@30c. per lb.

### VEGETABLE OILS

Leading crushers of *linseed oil* advanced prices 2c. per gal. to a basis of 71c. per gal. in carload quantities, for prompt and forward shipments, the rise being in sympathy with the seed. The demand, however, fell away at the close of the week and the undertone was barely steady. Bids were in the market at 69c. per gal., but these were turned down. Higher prices for imported oil were a feature of the market. English oil was offered at 62½c. per gal., duty paid, January shipment. Dutch oil was available for prompt shipment at 62c. per gal., duty paid. Sales of spot *chinawood oil* were recorded at 12½c. per lb. for carload lots. On lesser quantities 13@13½c. was quoted. January delivery oil closed at 13½c., with February held at 12½c. There was a firmer market for crude *peanut oil*, prices closing a fraction of a cent higher on prime goods. Holders of prime stocks were asking 7½@8½c. per lb., buyers' tanks, f.o.b. mills. Refined oil in barrels, for prompt shipment, closed at 10½@11c. per lb. The market for English refined *rapeseed oil* was steady at 82@84c. per gal. in barrels. Dutch oil was offered at 81c. Future prices held around 78@80c. per gal. Scattered lots of resale *soya bean oil* were offered at 7@7½c. per lb., sellers' tanks, f.o.b. coast. The market was dull and featureless.

## The Chicago Market

CHICAGO, Ill., Jan. 13, 1922.

An improvement can be noticed in the general condition of the industrial chemical market, but as yet it has failed to show the big increase of business looked for after the first of January. It is quite evident, however, that better times are coming for the chemical trade, and it is to be hoped that things will pick up gradually rather than all at once. Stocks are all low and a sudden rush of business would surely cause an acute shortage, which in turn would send prices upward. Today prices were noticeably firm, with little or no tendency to shade regular quotations.

### GENERAL CHEMICALS

The alkalis are moving only in a routine way and while no pressure to sell was evident several holders reduced their prices. *Solid caustic soda* was quoted at \$3.75 per 100 lb. for the 76 per cent material in ton lots and similar quantities of the ground at \$4.50. *Caustic potash* is very firm at \$6.50 per 100 lb. for 88-92 per cent material. Leading factors in this market expect higher prices very soon due to the increasing costs abroad. *Soda ash* is quoted at \$2.60 per 100 lb. basis cooperage and is moving only in small lots.

*Potash alum* is unchanged as to price and is in moderate demand at 5½¢ per lb. for the lump and 6¢ for the powdered. *Ammonium carbonate* is very quiet and unchanged at 9¢ per lb. for the lump in casks. *White arsenic* is very firm and material at 7¢. was difficult to locate. *Barium chloride* is firm but with a small demand. The imported white crystals are quoted at \$60 per ton spot delivery. *Bleach* is firm and is moving in a routine way at 3¢ per lb. for large drums. *Copper sulphate* is a firm item and is moving in a fair way at 6¢ per lb. *Glycerine* is one of the strongest items on the list and the c.p. material is scarce at 16½¢-17¢ per lb.

*Potash bichromate* is in fair request, and supplies are available at 12¢ per lb. *Sodium bichromate* is very firm, and while one factor held to 9¢ per lb., most of the others advanced their ideas to 9½¢. The *prussiates of potash* continue firm and scarce. The best that could be done on the red was 31¢. and on the yellow 26¢.

The acid market shows no change and is still very dull. *Acetic acid* is unchanged in price, with very little moving. The same is true of the heavy acids, where only small lots are moving in carboys.

### VEGETABLE OILS

*Linseed oil* is reported to be moving in a fair way and the inquiry especially from the paint trade to be much improved. The boiled oil is today quoted at 80¢ per gal. in 5-bbl. lots and the raw at 78¢.

### NAVAL STORES

Dealers in naval stores report business as good. *Turpentine* is receiving a good inquiry and is moving in a satisfactory volume. Today's quotation was 91¢ per gal. in 5-bbl. lots. *Rosins* are moving very well and the WW grade is quoted at \$9 per 280 lb. in less than carlots.

## The Iron and Steel Market

PITTSBURGH, Jan. 13, 1922.

While the finished steel markets are commonly described as having been particularly quiet since the middle of December, there is really a fair amount of business being placed at mills. Buyers as a whole have curtailed their purchases somewhat on account of inventory taking, but the influence of this annual operation is perhaps overrated.

Except for the influence of the winter season the fundamental conditions as to steel consumption are substantially unaltered. Demand for oil country goods, which kept up remarkably well until a few weeks ago, is now lighter, but will presumably resume its former gait before the opening of spring.

### DIP IN STEEL PRODUCTION

On account of the close connection between the steel mill and ultimate consumption of steel, due to buyers having reduced their stocks to a minimum and adopted

the practice of ordering from hand to mouth, frequently in single carloads with mixed specifications, steel production has had a dip in harmony with seasonally decreased consumption that has not ordinarily been noticed at this time of year. Production of steel ingots in October was at the rate of 23,000,000 tons a year, November showing an average rate a trifle higher. The American Iron and Steel Institute report for December, just distributed, giving the production of thirty companies, indicates that the average rate in the month was about 20,000,000 tons, which of course means a considerably higher rate at the opening of the month and a considerably lower rate at the close. From this lower rate a recovery has set in this week. January production may possibly not exceed that of December, but in February and March the rate should easily be as great as the rate in October and November, with chances of further increases.

### LITTLE RAILROAD BUYING

While the financial condition of the railroads has been steadily improving, there is still but little railroad buying in steel and steel products. The Union Pacific has ordered 4,500 freight cars and the Illinois Central 2,000. Rail orders for 1922 are being placed with more reserve than expected, but in a year's steel business this is of no material importance, since the difference between a close and a liberal policy in replacements is only a very few hundreds of thousands of tons.

The leading interest has booked a large amount of tin plate business for a single week, from large customers in position to act freely in the light of their business prospects. Sheets are decidedly quiet, but a fair volume of business is being placed. The automobile trade is beginning to buy more freely in sheets and other descriptions of steel. Agricultural implement factories, for many months conspicuous by their complete absence from the steel market, are buying in a very small way. One of the poorest features of the general situation is the inability of the farmer to buy, this being important since normally the farm is a large consumer of steel in various forms.

### STEEL PRICES

Finished steel prices continue to exhibit the steadiness that has characterized them for several weeks past, the condition being in strong contrast with that seen for many months. Price changes are now quite infrequent, while the margin between prices done on small orders and on large orders is quite narrow. The market in general is quotable as follows: Bars, shapes and plates, 1.50¢; hoops, bands and hot-rolled strips, 2¢; plain wire, 2.25¢; wire nails, \$2.50; standard steel pipe, 71 per cent basing discount; black sheets, 3¢; galvanized sheets, 4¢; tin plate, \$4.75.

W. P. Snyder & Co., operating the Shenango furnaces, have sold 1,500 tons of bessemer pig iron to an Ohio consumer at \$19.50 valley. This is the first sale of bessemer of any consequence for quite a while, and establishes a market price, the market having for some time past been quotable nominal at \$20 valley. Basic remains quotable at \$18.25 valley, and foundry at \$19.50 valley.

### COKE

Cornellsville furnace coke has stiffened in the spot market and weakened in the contract market, bringing the two close together, as they should be. It would be difficult now to pick up a regular lot of spot coke at under about \$3, while a first quarter contract has been made, with an Eastern consumer, at \$3.10. Recently spot coke was quoted as low as \$2.75, while at the same time first quarter contracts were made all the way from \$3.25 to \$3.40 and perhaps \$3.50.

### STEEL SCRAP

Dealers freely bid \$14.50, delivered Pittsburgh, for heavy melting steel scrap and they might pay a trifle more. On round lots to consumers it is unlikely less than about \$15.50 could be done. The mills are not in the market at present.

## General Chemicals

## CURRENT WHOLESALE PRICES IN NEW YORK MARKET

	Carlots	Less Carlots
Acetic anhydride, lb.		\$0.40 - \$0.45
Acetone, lb.	\$0.12 - \$0.12	13 - 13
Acid, acetic, 28 per cent, 100 lbs.	2.50 - 2.60	2.65 - 3.00
Acetic, 56 per cent, 100 lbs.	5.00 - 5.25	5.30 - 5.50
Acetic, glacial, 99 per cent, carboys, 100 lbs.	10.00 - 10.50	10.75 - 11.00
Boric, crystals, lb.	12 - 12	13 - 13
Boric, powder, lb.	12 - 13	13 - 14
Citric, lb.		44 - 45
Hydrochloric, 100 lb.	1.50 - 1.60	1.65 - 2.00
Hydrofluoric, 52 per cent, lb.	12 - 12	13 - 13
Lactic, 44 per cent tech, lb.	09 - 10	10 - 12
Lactic, 22 per cent tech, lb.	04 - 04	04 - 05
Molybdic, e.p., lb.	3.00 - 3.25	3.30 - 3.75
Muriatic, 20 deg. (see hydrochloric)		
Nitric, 40 deg., lb.	06 - 06	06 - 07
Nitric, 42 deg., lb.	06 - 07	07 - 07
Oxalic, crystals, lb.	14 - 14	14 - 15
Phosphoric, 50 per cent solution, lb.	10 - 10	10 - 11
Picric, lb.	20 - 25	27 - 35
Pyrogallol, resublimed, lb.		1.65 - 1.75
Sulphuric, 60 deg., tank cars, ton		11.00 - 12.00
Sulphuric, 60 deg., drums, ton		13.00 - 15.00
Sulphuric, 66 deg., tank cars, ton	16.50 - 17.00	
Sulphuric, 66 deg., drums, ton	21.00 - 22.00	22.50 - 23.00
Sulphuric, 66 deg., carboys, ton		
Sulphuric, fuming, 20 per cent (oleum), tank cars, ton	21.00 - 22.00	
Sulphuric, fuming, 20 per cent (oleum), drums, ton	23.00 - 23.50	24.00 - 24.50
Sulphuric, fuming, 20 per cent (oleum), carboys, ton	31.00 - 32.00	33.00 - 34.00
Tannic, U. S. P., lb.		65 - 75
Tannic (tech.), lb.	45 - 50	51 - 55
Tartaric, imported crystals, lb.		25 - 26
Tartaric acid, imported, powdered, lb.		26 - 27
Tartaric acid, domestic, lb.		31 - 32
Tungstic, per lb. of WO <sub>3</sub> , lb.		1.00 - 1.10
Alcohol, ethyl, gal.		4.75 - 5.50
Alcohol, methyl (see methanol)		
Alcohol, denatured, 188 proof, gal.		41 - 42
Alcohol, denatured, 190 proof, gal.		43 - 44
Alum, ammonia, lump, lb.	03 - 03	04 - 04
Alum, potash, lump, lb.	03 - 04	04 - 04
Alum, chrome lump, lb.	07 - 08	08 - 08
Aluminum sulphate, commercial, lb.	01 - 02	02 - 02
Aluminum sulphate, iron free, lb.	02 - 02	03 - 03
Aqua ammonia, 26 deg. drums (750 lb.), lb.	07 - 07	08 - 08
Ammonia, anhydrous, cyl. (100-150 lb.), lb.	30 - 30	31 - 33
Ammonium carbonate, powder, lb.	07 - 07	08 - 09
Ammonium chloride, granular (white sal ammoniac), lb.	06 - 06	06 - 07
Ammonium chloride, granular (gray sal ammoniac), lb.	06 - 06	07 - 07
Ammonium nitrate, lb.	07 - 07	07 - 08
Amylacetate tech, gal.		2.00 - 2.40
Arsenic oxide, (white arsenic) powdered, lb.	07 - 07	07 - 08
Arsenic sulphide, powdered (red arsenic), lb.	12 - 12	12 - 13
Barium chloride, ton	50.00 - 51.00	52.00 - 60.00
Barium dioxide (peroxide), lb.	21 - 21	22 - 23
Barium nitrate, lb.	06 - 07	07 - 08
Barium sulphate (precip.) (blanc fixe), lb.	03 - 04	04 - 04
Blanc fixe, dry, ton		
Blanc fixe, pulp, ton	45.00 - 55.00	
Bleaching powder (see calc. hypochlorite)		
Blue vitriol (see copper sulphate)		
Borax (see sodium borate)		
Bromine (see sulphur, roll)		
Bromine, lb.	21 - 22	23 - 28
Calcium acetate, 100 lbs.	1.75 - 2.00	
Calcium carbide, lb.	04 - 04	05 - 05
Calcium chloride, fused, lump, ton	23.00 - 24.00	24.50 - 28.00
Calcium chloride, granulated, lb.	01 - 02	02 - 02
Calcium hypochlorite (bleach g powder), 100 lb.	2.25 - 2.40	2.50 - 3.25
Calcium peroxide, lb.		1.40 - 1.50
Calcium phosphate, tribasic, lb.		15 - 16
Camphor, lb.		90 - 95
Carbon bisulphide, lb.	06 - 06	06 - 07
Carbon tetrachloride, drums, lb.	10 - 10	11 - 12
Carbonyl chloride, (phosgene), lb.		60 - 75
Caustic potash (see potassium hydroxide)		
Caustic soda (see sodium hydroxide)		
Chalk, precip., domestic, light, lb.	03 - 04	
Chalk, precip., domestic, heavy, lb.	03 - 03	
Chalk, precip., imported, light, lb.	04 - 04	
Chlorine, gas, liquid-cylinders (100 lb.), lb.	06 - 06	06 - 07
Chloroform, lb.		38 - 40
Cobalt oxide, lb.		2.00 - 2.10
Copperas (see iron sulphate)		
Copper carbonate, green precipitate, lb.	20 - 20	21 - 21
Copper cyanide, lb.		58 - 60
Copper sulphate, crystals, 100 lb.	5.60 - 5.65	5.70 - 6.25
Cream of tartar (see potassium bitartrate)		
Epsom salt (see magnesium sulphate)		
Ethyl acetate com. 85%, gal.		60 - 70
Ethyl acetate, pure (acetic ether, 98% to 100%), gal.		95 - 112
Formaldehyde, 40 per cent, lb.	10 - 11	
Fullers earth, f.o.b. mines, net ton	16.00 - 17.00	
Fullers earth-imported powdered-net ton	30.00 - 32.00	
Fusel oil, ref., gal.		2.50 - 3.00
Fusel oil, crude, gal.		1.50 - 1.75
Glauber's salt (see sodium sulphate)		
Glycerine, e. p. drums extra, lb.		16 - 17
Iodine, resublimed, lb.		3.80 - 3.90
Iron oxide, red, lb.		12 - 18
Iron sulphate (copperas), ton	15.00 - 16.00	17.00 - 20.00
Lead acetate, lb.		10 - 12
Lead arsenate, powd., lb.	15 - 15	15 - 16
Lead nitrate, lb.		15 - 20
Litharge, lb.	08 - 08	08 - 09
Magnesium carbonate, technical, lb.	06 - 07	07 - 08
Magnesium sulphate, U. S. P., 100 lb.	2.65 - 2.70	2.75 - 3.00
Magnesium sulphate, technical, 100 lb.		1.05 - 1.80
Methanol, 95%, gal.		61 - 62

	Carlots	Less Carlots
Methanol, 97%, gal.	\$ - \$	\$0.63 - \$0.64
Nickel salt, double, lb.		11 - 11
Nickel salt, single, lb.		12 - 12
Phosgene (see carbonyl chloride)		
Phosphorus, red, lb.	45 - 46	47 - 50
Phosphorus, yellow, lb.		30 - 35
Potassium bichromate, lb.	10 - 10	10 - 11
Potassium bitartrate (cream of tartar), lb.		24 - 26
Potassium bromide, granular, lb.		14 - 18
Potassium carbonate, U. S. P., lb.	11 - 12	12 - 15
Potassium carbonate, 80-85%, lb.	04 - 04	05 - 06
Potassium chlorate, crystals, lb.	05 - 06	06 - 12
Potassium cyanide, lb.		43 - 45
Potassium hydroxide (caustic potash), lb.	06 - 06	06 - 06
Potassium iodide, lb.		2.90 - 3.00
Potassium nitrate, lb.	07 - 07	08 - 09
Potassium permanganate, lb.	14 - 15	16 - 22
Potassium prussiate, red, lb.	29 - 30	30 - 31
Potassium prussiate, yellow, lb.	24 - 24	25 - 26
Rochelle salts (see sodium potas. tartrate)		
Sal ammoniac (see ammonium chloride)		
Sal soda (see sodium carbonate)		
Salt cake (bulk), ton		18.00 - 21.00
Soda ash, light, 100 lb.	1.75 - 2.00	2.05 - 2.40
Soda ash, dense, 100 lb.	2.05 - 2.10	2.15 - 2.40
Sodium acetate, lb.	04 - 04	05 - 05
Sodium bicarbonate, 100 lb.	2.30 - 2.35	2.40 - 2.75
Sodium bichromate, lb.	07 - 08	08 - 08
Sodium bisulphate (nitre cake), ton	4.75 - 5.00	5.25 - 6.00
Sodium bisulphite powdered, U.S.P., lb.	04 - 05	05 - 06
Sodium borate (borax), lb.	05 - 06	06 - 07
Sodium carbonate (sal soda), 100 lb.	1.80 - 1.90	1.95 - 2.15
Sodium chloride, lb.	06 - 06	07 - 07
Sodium chloride, long ton	12.00 - 13.00	
Sodium cyanide, lb.	26 - 26	26 - 27
Sodium fluoride, lb.	10 - 11	11 - 12
Sodium hydroxide (caustic soda), 100 lb.	3.75 - 3.80	3.85 - 4.25
Sodium hyposulphite, lb.		03 - 03
Sodium nitrite, lb.	06 - 06	07 - 07
Sodium peroxide, powdered, lb.	25 - 26	27 - 30
Sodium phosphate, dibasic, lb.	04 - 04	04 - 05
Sodium potassium tartrate (Rochelle salts), lb.	17 - 17	17 - 18
Sodium prussiate, yellow, lb.		17 - 18
Sodium silicate, solution (40 deg.), 100 lb.	1.00 - 1.05	1.10 - 1.30
Sodium silicate, solution (60 deg.), 100 lb.	2.25 - 2.40	2.45 - 2.75
Sodium sulphate, crystals (glaubers salt) 100 lb.	1.25 - 1.30	1.35 - 2.00
Sodium sulphide, fused, 60-62 per cent (conc.), lb.	04 - 04	04 - 05
Sodium sulphite, crystals, lb.	03 - 03	04 - 04
Strontium nitrate, powdered, lb.	10 - 11	11 - 15
Sulphur chl. ride, red, lb.	05 - 05	05 - 06
Sulphur, crude, ton	18.00 - 20.00	
Sulphur dioxide, liquid, cylinders extra, lb.	08 - 08	09 - 10
Sulphur (sublimed), flour, 100 lb.		2.25 - 3.10
Sulphur, roll (brimstone), 100 lb.		2.00 - 2.75
Talc-imported, ton	30.00 - 40.00	
Talc-domestic powdered, ton	18.00 - 25.00	
Tin bichloride, lb.	09 - 09	09 - 10
Tin oxide, lb.		39 - 40
Zinc carbonate, lb.	14 - 14	15 - 16
Zinc chloride, gran., lb.	09 - 09	09 - 10
Zinc cyanide, lb.	42 - 44	45 - 47
Zinc dust, lb.	11 - 11	11 - 12
Zinc oxide, XX, lb.	07 - 07	08 - 09
Zinc sulphate, 100 lb.	3.00 - 3.25	3.30 - 3.50

## Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha-naphthol, crude, lb.	\$1.00 - \$1.05
Alpha-naphthol, refined, lb.	1.15 - 1.20
Alpha-naphthylamine, lb.	28 - 30
Aniline oil, drums extra, lb.	18 - 19
Aniline salts, lb.	25 - 26
Anthracene, 80% in drums (100 lb.), lb.	75 - 1.00
Benzaldehyde U.S.P., lb.	1.35 - 1.45
Benzidine, base, lb.	85 - 95
Benzidine sulphate, lb.	75 - 85
Benzoic acid, U.S.P., lb.	60 - 65
Benzoate of soda, U.S.P., lb.	52 - 55
Benzene, pure, water-white, in drums (100 gal.), gal.	29 - 35
Benzene, 90%, in drums (100 gal.), gal.	27 - 32
Benzyl chloride, 95-97%, refined, lb.	25 - 27
Benzyl chloride, tech., lb.	20 - 23
Beta-naphthol benzoate, lb.	3.75 - 4.00
Beta-naphthol, sublimed, lb.	70 - 75
Beta-naphthol, tech, lb.	32 - 34
Beta-naphthylamine, sublimed, lb.	1.50 - 1.60
Cresol, U. S. P., in drums (100 lb.), lb.	16 - 17
Ortho-cresol, in drums (100 lb.), lb.	24 - 26
Cresylic acid, 97-99%, straw color, in drums, gal.	70 - 80
Cresylic acid, 75-97%, dark, in drums, gal.	65 - 70
Cresylic acid, 50%, first quality, drums, gal.	45 - 50
Dichlorobenzene, lb.	66 - 69
Diethyl aniline, lb.	90 - 1.05
Dimethylaniline, lb.	40 - 45
Dinitrobenzene, lb.	21 - 25
Dinitrochlorobenzene, lb.	25 - 27
Dinitronaphthalene, lb.	32 - 35
Dinitrophenol, lb.	38 - 40
Dinitrotoluene, lb.	25 - 30
Dip oil, 25%, ear lots, in drums, gal.	31 - 35
Diphenylamine, lb.	60 - 70
H-acid, lb.	1.00 - 1.10
Meta-phenylenediamine, lb.	1.10 - 1.15
Monochlorobenzene, lb.	10 - 12
Monothylaniline, lb.	1.40 - 1.45
Naphthalene crushed, in bbls, lb.	07 - 08
Naphthalene, flake, lb.	07 - 08
Naphthalene, balls, lb.	08 - 09
Naphthionic acid, crude, lb.	65 - 70
Nitrobenzene, lb.	11 - 14
Nitro-naphthalene, lb.	30 - 35
Nitro-toluene, lb.	15 - 17
Ortho-amidophenol, lb.	3.00 - 3.10
Ortho-dichlorobenzene, lb.	15 - 20
Ortho-nitro-phenol, lb.	75 - 80
Ortho-nitro-toluene, lb.	15 - 20

Ortho-toluidine.....	lb.	.20	—	.25
Para-amidophenol, base.....	lb.	1.30	—	1.35
Para-amidophenol, HCl.....	lb.	1.60	—	1.70
Para-dichlorobenzene.....	lb.	.15	—	.17
Paranitroaniline.....	lb.	.77	—	.80
Para-nitrotoluene.....	lb.	.75	—	.80
Para-phenylenediamine.....	lb.	1.65	—	1.70
Para-toluidine.....	lb.	1.15	—	1.25
Phthalic anhydride.....	lb.	.37	—	.40
Phenol, U. S. P., drums.....	lb.	.11	—	.15
Pyridine.....	gal.	1.75	—	2.75
Resorcinol, technical.....	lb.	1.50	—	1.60
Resorcinol, pure.....	lb.	2.00	—	2.25
Salicylic acid, tech., in bbls.....	lb.	.20	—	.21
Salicylic acid, U. S. P.....	lb.	.22	—	.23
Salol.....	lb.	.75	—	.77
Solvent naphtha, water-white, in drums, 100 gal.....	gal.	.25	—	.28
Solvent naphtha, crude, heavy, in drums, 100 gal.....	gal.	.14	—	.16
Sulphanilic acid, crude.....	lb.	.26	—	.28
Toluidine.....	lb.	1.20	—	1.30
Toluidine, mixed.....	lb.	.32	—	.38
Toluene, in tank cars.....	gal.	.25	—	.28
Toluene, in drums.....	gal.	.30	—	.35
Xyldines, drums, 100 gal.....	lb.	.40	—	.45
Xylene, pure, in drums.....	gal.	.40	—	.45
Xylene, pure, in tank cars.....	gal.	.45	—	.....
Xylene, commercial, in drums, 100 gal.....	gal.	.33	—	.35
Xylene, commercial, in tank cars.....	gal.	.30	—	.....

### Waxes

Prices based on original packages in large quantities.

Bayberry Wax.....	lb.	\$0.20	—	\$0.21
Beeswax, refined, dark.....	lb.	.24	—	.25
Beeswax, refined, light.....	lb.	.28	—	.30
Beeswax, white pure.....	lb.	.34	—	.38
Candelilla wax.....	lb.	.23	—	.24
Carnauba, No. 1.....	lb.	.45	—	.46
Carnauba, No. 2, North Country.....	lb.	.22	—	.22
Carnauba, No. 3, North Country.....	lb.	.13	—	.14
Japan.....	lb.	.19	—	.20
Montan, crude.....	lb.	.04	—	.05
Paraffine waxes, crude match wax (white) 105-110 m.p.....	lb.	.04	—	.04
Paraffine waxes, crude, scale 124-126 m.p.....	lb.	.03	—	.03
Paraffine waxes, refined, 118-120 m.p.....	lb.	.03	—	.03
Paraffine waxes, refined, 125 m.p.....	lb.	.03	—	.03
Paraffine waxes, refined, 128-130 m.p.....	lb.	.04	—	.04
Paraffine waxes, refined, 133-135 m.p.....	lb.	.04	—	.05
Paraffine waxes, refined, 135-137 m.p.....	lb.	.05	—	.05
Stearic acid, single pressed.....	lb.	.09	—	.....
Stearic acid, double pressed.....	lb.	.09	—	.....
Stearic acid, triple pressed.....	lb.	.10	—	.10

### Naval Stores

All prices are f.o.b. New York unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Rosin B-D, bbl.....	280 lb.	\$5.20	—	5.25
Rosin E-I.....	280 lb.	5.30	—	5.40
Rosin K-N.....	280 lb.	5.95	—	6.65
Rosin W, G., W. W.....	280 lb.	7.00	—	7.25
Wood rosin, bbl.....	280 lb.	6.25	—	.....
Spirits of turpentine.....	gal.	.90	—	.....
Wood turpentine, steam dist.....	gal.	.88	—	.....
Wood turpentine, dest. dist.....	gal.	.87	—	.....
Pine tar pitch, bbl.....	200 lb.	.....	—	8.00
Tar, kila burned, bbl. (500 lb.).....	bbl.	.....	—	10.00
Retort tar, bbl.....	500 lb.	.....	—	9.00
Rosin oil, first run.....	gal.	.36	—	.....
Rosin oil, second run.....	gal.	.39	—	.....
Rosin oil, third run.....	gal.	.46	—	.....
Pine oil, steam dist., sp.gr. 0.930-0.940.....	gal.	\$1.90	—	.....
Pine oil, pure, dest. dist.....	gal.	1.50	—	.....
Pine tar oil, ref., sp.gr. 1.025-1.035.....	gal.	.46	—	.....
Pine tar oil, crude, sp.gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.....	gal.	.35	—	.....
Pine tar oil, double ref., sp.gr. 0.965-0.990.....	gal.	.75	—	.....
Pine tar, ref., thin, sp.gr. 1.080-1.060.....	gal.	.35	—	.....
Turpentine, crude, sp.gr. 0.900-0.970.....	gal.	1.25	—	.....
Hardwood oil, f.o.b. Mich., sp.gr. 0.960-0.990.....	gal.	.35	—	.....
Pinewood creosote, ref.....	gal.	.52	—	.....

### Fertilizers

Ammonium sulphate, bulk and doub'e bags.....	100 lb.	\$2.30	—	2.90
Blood, dried, f.o.b., N. Y.....	unit	4.00	—	.....
Bone, 3 and 50, ground, raw.....	ton	30.00	—	32.00
Fish scrap, dom., dried, f.o.b. works.....	unit	2.90	—	3.00
Nitrate soda.....	100 lb.	2.35	—	2.40
Tankage, high grade, f.o.b. Chicago.....	unit	2.75	—	3.00
Phosphate rock, f.o.b. mines, Florida pebble, 68-72%.....	ton	4.50	—	6.50
Tennessee, 78-80%.....	ton	8.50	—	9.00
Potassium muriate, 80%.....	ton	34.00	—	35.00
Potassium sulphate.....	unit	.95	—	1.00

### Crude Rubber

Para-Upriver fine.....	lb.	\$0.23	—	.23
Upriver coarse.....	lb.	.13	—	.14
Upriver caucho ball.....	lb.	.13	—	.13
Plantation—First latex crepe.....	lb.	.18	—	.18
Ribbed smoked sheets.....	lb.	.18	—	.19
Brown crepe, thin, clean.....	lb.	.15	—	.....
Amber crepe No. 1.....	lb.	.17	—	.....

### Oils

#### VEGETABLE

The following prices are f.o.b. New York for carload lots.

Castor oil, No. 3, in bbls.....	lb.	\$0.10	—	\$0.10
Castor oil, AA, in bbls.....	lb.	.11	—	.12
China wood oil, in bbls. (f.o.b. Pac. coast).....	lb.	.12	—	.13
Coconut oil, Ceylon grade, in bbls.....	lb.	.09	—	.09
Coconut oil, Cochon grade, in bbls.....	lb.	.10	—	.10
Corn oil, crude, in bbls.....	lb.	.08	—	.08
Cottonseed oil, crude (f. o. b. mill).....	lb.	.07	—	.07
Cottonseed oil, summer yellow.....	lb.	.08	—	.09
Cottonseed oil, winter yellow.....	lb.	.09	—	.09
Linseed oil, raw, ear lots (domestic).....	gal.	.71	—	.72
Linseed oil, raw, tank cars (domestic).....	gal.	.66	—	.67
Linseed oil, in 5-bbl lots (domestic).....	gal.	.74	—	.75
Olive oil, denatured.....	gal.	\$1.15	—	\$1.20
Palm, Lagos.....	lb.	.08	—	.08
Palm, Niger.....	lb.	.05	—	.06
Peanut oil, crude, tank cars (f.o.b. mill).....	lb.	.07	—	.07
Peanut oil, refined, in bbls.....	lb.	.10	—	.11
Rapeseed oil, refined in bbls.....	gal.	.82	—	.83
Rapeseed oil, blown, in bbls.....	gal.	.87	—	.89
Soya bean oil (Manchurian), in bbls, N. Y.....	lb.	.08	—	.....
Soya bean oil, tank cars, f.o.b., Pacific coast.....	lb.	.07	—	.....

#### FISH

Light pressed menhaden.....	gal.	\$0.46	—	.....
Yellow bleached menhaden.....	gal.	.48	—	.....
White bleached menhaden.....	gal.	.50	—	.....
Blown menhaden.....	gal.	.57	—	.....

### Miscellaneous Materials

Prices remain unchanged throughout the list.

#### Refractories

All prices remain the same as figures appearing in our Dec. 28 issue.

#### Ferro-Alloys

All f.o.b. Works

Ferrocobalt-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.....	net ton	\$200.00	—	\$225.00
Ferrocobalt, per lb. of Cr contained, 6-8% carbon, earlots.....	lb.	.11	—	.....
Ferrocobalt, per lb. of Cr contained, 4-6% carbon, earlots.....	lb.	.12	—	.....
Ferromanganese, 76-80% Mn, domestic.....	gross ton	58.00	—	60.00
Ferromanganese, 76-80% Mn, Foreign, c. i. f. Atlantic seaport.....	gross ton	54.00	—	58.35
Spiegelisen, 18-22% Mn.....	gross ton	25.00	—	27.00
Ferromolybdenum, 50-60% Mo, per lb. of Mo.....	lb.	2.25	—	.....
Ferrosilicon, 10-15%.....	gross ton	38.00	—	40.00
Ferrosilicon, 50%.....	gross ton	57.00	—	59.00
Ferrosilicon, 75%.....	gross ton	115.00	—	120.00
Ferrotungsten, 70-80% per lb. of contained W.....	lb.	.40	—	.45
Ferro-uranium, 35-50% of U, per lb. of U content.....	lb.	6.00	—	.....
Ferrovanadium, 30-40% per lb. of contained V.....	lb.	4.25	—	4.50

### Ores and Semi-finished Products

Prices remain quotably unchanged as of Jan. 11

#### Non-Ferrous Metals

New York Markets

Cents per Lb.

Copper, electrolytic.....	13.75
Aluminum, 98 to 99 per cent.....	19.00
Antimony, wholesale lots, Chinese and Japanese.....	4.50
Nickel, ordinary (ingot).....	41.00
Nickel, electrolytic.....	44.00
Nickel, electrolytic, resale.....	35.00
Monel metal, shot and blocks.....	35.00
Monel metal, ingots.....	38.00
Monel metal, sheet bars.....	40.00
Tin, 5-ton lots, Straits.....	32.375
Lead, New York, spot.....	4.70
Lead, E. St. Louis, spot.....	4.375
Zinc, spot, New York.....	5.20
Zinc, spot, E. St. Louis.....	4.75

#### OTHER METALS

Silver (commercial).....	oz.	\$0.66
Cadmium.....	lb.	1.00-1.10
Bismuth (500 lb. lots).....	lb.	1.50@1.55
Cobalt.....	lb.	3.00@3.25
Platinum (f.o.b. Philadelphia).....	lb.	1.25
Magnesium.....	oz.	84.00-93.00
Iridium.....	oz.	150.00@170.00
Palladium.....	oz.	55.00-60.00
Mercury.....	75 lb.	52.00-53.00

#### FINISHED METAL PRODUCTS AND OLD METALS

Quotations have remained unchanged since our previous report.

### Structural Material

The following base prices per 100 lb. are for structural shapes 3 in. by 1/2 in. and larger, and plates 1/2 in. and heavier, from jobbers' warehouses in the cities named:

	New York	Cleveland	Chicago
Structural shapes.....	\$2.63	\$2.78	\$2.78
Soft steel bars.....	2.53	2.68	2.68
Soft steel bar shapes.....	2.53	2.68	2.68
Soft steel bands.....	3.13	3.28	3.28
Plates, 1/2 to 1 in. thick.....	2.63	2.78	2.78

\*Add 15c per 100 lb. for trucking to Jersey City and 10c for delivery in New York and Brooklyn.

# Industrial

Financial, Construction and Manufacturers' News

## Construction and Operation

### Alabama

**BIRMINGHAM**—The White Star Cement & Coal Co., recently organized under Delaware laws with capital of \$3,000,000, has preliminary plans under way for the construction of a new cement-manufacturing plant in the vicinity of Birmingham, with total annual capacity to approximate 1,000,000 bbl. of material. The main office of the company will be located at Nazareth, Pa. A. G. Connolly is president, and Charles W. K. Shafer, secretary. Richard K. Meade & Co., 11 East Fayette St., Baltimore, Md., are engineers for the project.

### California

**OAKLAND**—Fuller & Goepp, 998 Monadnock Bldg., San Francisco, manufacturers of glass products, have plans under way for the construction of a new 2-story, reinforced-concrete plant at 11th and Jackson Sts., Oakland. Work will be commenced at an early date.

### Connecticut

**NEW HAVEN**—The Seamless Rubber Co., Hallock Ave., manufacturer of small rubber goods, is having plans prepared for the construction of a 1-story addition, 140 x 160 ft., with extension 60 x 60 ft., to be used as a spraying department, estimated to cost about \$100,000, with machinery. The company is also rebuilding the portion of its plant recently destroyed by fire, with loss estimated at about \$200,000. R. W. Foote, 185 Church St., is architect for the new building.

**BRIDGEPORT**—The Crane Co. has foundation work under way for the proposed 1-story addition to its local South End metal-working plant, 75 x 175 ft., for a new annealing department. Ten large annealing furnaces with auxiliary equipment will be installed. The extension will cost about \$50,000.

### Delaware

**WILMINGTON**—Fire recently destroyed buildings of the New Castle Leather Co. and Hercules Powder Co., East Tenth St., with loss estimated at about \$50,000 and \$15,000, respectively.

### Georgia

**MILLEDGEVILLE**—The Oconee Brick & Tile Co. is planning for extensions and improvements at the plant of the American Fireproofing Co., recently acquired. The capacity will be increased.

### Florida

**LEESBURG**—The Grass Fibre Pulp & Paper Corp., Leesburg, is considering the construction of a branch plant at Arcadia, Fla., for the manufacture of pulp and paper from saw-grass. E. R. Lacy is vice-president and general manager.

### Indiana

**INDIANAPOLIS**—The Piel Bros. Starch Co., State Life Bldg., has filed plans for the construction of an addition to its plant on Drover St., to cost about \$50,000. William F. Piel is president.

### Kentucky

**ASHLAND**—The City Council has commenced the construction of a new filtration plant for the waterworks system, to cost about \$250,000, including equipment. E. C. Means is city engineer in charge.

### Louisiana

**NEW ORLEANS**—The Celotex Co., manufacture of wall-board composition products from refuse sugar cane under a patented process, is considering plans for the construction of an addition to its plant for largely increased capacity; it is proposed to double the present output. A bond issue for \$500,000 is being arranged to provide funds for the expansion.

**LAKE LAND**—Fire Dec. 31 destroyed a portion of the refinery of the Ingleside Sugar Refining Co., with loss estimated

at about \$200,000, including buildings and machinery.

**MONROE**—The Owens Bottle Co., Toledo, O., has acquired property at Monroe as a site for the construction of a new plant for the manufacture of glass bottles and other containers. The proposed works will be equipped to give employment to about 500 men.

### Maryland

**BALTIMORE**—The Sherwood Brothers Co., Garrett Bldg., manufacturer of oil products, has acquired a large tract of land adjoining its plant in the Canton section, for the erection of an addition. A number of new buildings will be constructed and machinery installed, while a group of new steel tanks will be built to increase the storage capacity to about 1,000,000 gal. The company was incorporated recently with capital of \$1,000,000.

**WESTCHESTER**—Fire Dec. 29 destroyed a portion of the rendering plant of Frank Leidy, with loss estimated at about \$12,000.

**BALTIMORE**—The Fitch Dustdown Co., Cincinnati, O., manufacturer of sweeping compounds, is negotiating for property at Baltimore for the erection of a branch manufacturing plant. It will be equipped for a capacity of about 30,000 lb. of material per day. The Industrial Bureau of the local Board of Trade is interested in the enterprise.

### Massachusetts

**WORCESTER**—The American Steel & Wire Co. is completing plans for the erection of a 1-story addition to its North Works, to be equipped as a galvanizing department, estimated to cost about \$42,000. Practically all of the equipment to be installed will be electrically operated. The engineering department at the works is also preparing plans for other extensions, estimated to cost in excess of \$200,000. Charles E. Goodrich is chief engineer.

**FALL RIVER**—The Fall River Gas Works has preliminary plans under way for the construction of a new water-gas plant, with daily capacity of about 3,000,000 cu.ft. The board of directors recently voted an appropriation of \$500,000 for the work.

### Minnesota

**BABBITT**—The Mesabi Iron Co. is considering the erection of a new concentrating plant at its works, estimated to cost about \$30,000. W. G. Swart is general manager.

### Missouri

**KANSAS CITY**—The American Foundry & Mfg. Co., Kansas City Life Bldg., has awarded a contract to William R. Jewell, 227 Rialto Bldg., for the erection of a 1-story foundry and plant, 90 x 140 ft., at 18th and Manchester Aves., estimated to cost about \$30,000. The company is also considering the erection of two additional plant units, to cost about \$65,000. H. H. Akers is manager.

### New Jersey

**NEWARK**—The Celluloid Co., 290 Ferry St., has filed plans for the erection of a new 1-story plant, 71 x 110 ft., at 65-67 Westcott St., estimated to cost about \$45,000.

**NEWARK**—The J. H. Balmer Co., Passaic, N. J., manufacturer of earthenware bathroom fixtures, etc., has leased a portion of the building at 67 Hamilton St., Newark, for the establishment of a new branch plant. Possession will be taken at once.

**MILLINGTON**—The Asbestos Materials Co. will make immediate improvements and extensions to the local plant of the Bateman Co., recently acquired, and heretofore devoted to the manufacture of agricultural equipment. An addition will be erected to the main building on Central Ave. Machinery will be installed at an early date and operations inaugurated.

**JERSEY CITY**—Colgate & Co., 105 Hudson St., manufacturers of soaps, etc., have acquired a 2-story and basement building, with two large wings, at Montreal, Que., for the establishment of a new branch plant. The company is now building an

addition to its Jersey City factory to cost about \$140,000.

### New York

**BROOKLYN**—The Perfect Brick & Hollow Tile Co., 188 Montague St., is taking bids for the erection of a new 1-story plant on Grand St., 95 x 100 ft., estimated to cost about \$25,000. Silverstein & Infanger, 190 Montague St., are architects.

**NIAGARA FALLS**—The International Paper Co. has awarded a contract to the Electric Furnace Construction Co., 908 Chestnut St., Philadelphia, Pa., for the installation of a new 6,000-kw. electric-steam generator at its local mill, with auxiliary operating equipment.

**BUFFALO**—The city waterworks department, Commissioner Kreinheder, will soon commence surveys for a new filtration plant at the foot of Jersey St., near the Porter Ave. pumping station of the waterworks, estimated to cost about \$4,500,000. An appropriation of this amount has been arranged for the project.

### Ohio

**NARLO**—Following the recent acquisition of the Dolomite Products Co., Narlo, by the Kelley Island Lime & Transport Co., Leader Bldg., Cleveland, plans are said to be in progress to increase the production of limestone at the local plant, effecting a total capacity of about 2,500 tons a day.

### Oklahoma

**PICHER**—Fire Dec. 26 destroyed the local Plant No. 2 of the Skelton Lead & Zinc Co., with loss estimated in excess of \$50,000, including equipment.

**TULSA**—Cosden & Co. are planning for a number of extensions in their local oil refinery, estimated to cost in excess of \$1,000,000. The Eastern office of the company is at 120 Broadway, New York.

### Pennsylvania

**PITTSBURGH**—The Standard Sanitary Mfg. Co., Bessemer Bldg., has awarded a contract to the B. A. Groah Construction Co., 847 West North Ave., for the construction of a 1-story addition to its sanitary ware-manufacturing plant on Preble Ave., 115 x 130 ft. It will be equipped as a plating department.

**PHILADELPHIA**—The David Berg Industrial Alcohol Co., Delaware Ave. and Tasker St., has acquired property adjoining its plant, 460 ft. wide, and of irregular depth, for a consideration said to be \$155,000, and will use the site for expansion.

### Tennessee

**CHATTANOOGA**—The Central Glass Co., 4240 Ogden Ave., Chicago, Ill., with plant at North Chattanooga, has acquired the local works of the DeCamp Glass Casket Co., which has been under a receivership for about a year past, with J. H. McCallum acting as trustee in bankruptcy. The acquired plant represents an investment of over \$200,000, and was secured for a consideration said to be about \$55,000. It will be used by the new owner for the manufacture of glass caskets, glass shingles and kindred products. It is proposed to inaugurate operations at an early date.

**LA FOLLETTE**—The LaFollette Coal & Iron Co. has preliminary plans under way for the construction of a new byproduct coke plant at its local works. The main feature of operation will be devoted to fuel carbonization, with output to aggregate over 400 tons per day. The plant is estimated to cost in excess of \$500,000. Parker & Wilder, Cincinnati, O., are engineers.

### Texas

**PORT NECHES**—The Humphreys-Pure Oil Refineries Corp., recently organized under Delaware laws with capital of \$50,000,000, is selecting a site at Port Neches for its proposed new oil refinery, on the Gulf. The plant is estimated to cost close to \$1,000,000, and will form the terminus of the company's new pipe line from the Mexia fields. It will be operated in conjunction with a proposed oil refinery at Houston, Tex., estimated to cost a like amount. Colonel E. A. Humphreys is president.

### Virginia

**NEW MARKET**—Fire Jan. 4 destroyed a portion of the flour mill of M. Driver & Bro., Lacey Spring, near New Market, with loss reported at about \$25,000.

### Washington

**SEATTLE**—The Goodyear Rubber Co. has leased a new 2-story factory, 50 x 110 ft., to be erected by the Great Northern Construction Co., New York Bldg., at Terry Ave. and Harrison St., for the establishment of a local works.

## Capital Increases, Etc.

**THE STORM STEEL BALL CO.**, 621 Harr Pl., Oak Park, Chicago, Ill., has filed notice of increase in capital from \$150,000 to \$250,000.

**THE MIDDLE STATES OIL CORP.**, Ardmore, Okla., is arranging for an increase in capital from \$16,000,000 to \$30,000,000.

**THE RUBBER SHOCK INSULATOR CO.**, a Delaware corporation, has filed notice of intention to operate in New York for the manufacture of rubber specialties, with capital of 2,500 shares of stock, no par value. W. Gutterston, 252 West 64th St., New York, represents the company.

**THE INTERNATIONAL PAPER CO.**, 30 Broad St., New York, N. Y., has arranged for a bond issue of \$12,500,000, for financing, general operations, etc.

**THE GUNNASH CHEMICAL WORKS**, 67 Margaretta St., Newark, N. J., has been declared insolvent, with liabilities totaling about \$11,000 over assets.

**THE ASSOCIATED PRODUCING & REFINING CORP.**, St. Louis, Mo., manufacturer of oil products, has filed notice of increase in capital from \$2,000,000 to \$50,000,000.

**THE SKELLY OIL CO.**, Tulsa, Okla., has arranged for a bond issue of \$3,500,000, the proceeds to be used for financing, general operations, etc. W. G. Skelly is president.

The tannery of the **VICTOR LEATHER CO.**, Auburn St., Allentown, Pa., manufacturer of glazed kid, bankrupt, will be sold by the receiver, George H. McNeely, 172 North 4th St., Philadelphia, Pa. The sale will include buildings, land and machinery.

**THE HOLLAND-ST. LOUIS SUGAR CO.**, Holland, Mich., operating refineries at Decatur, Ind., and St. Louis, Mich., has arranged for a bond issue of \$1,300,000, the proceeds to be used for financing, general operations, etc.

## New Companies

**F. R. HENDERSON & CO., INC.**, New York, N. Y., has been incorporated with a capital of \$1,000,000, to manufacture rubber products. The incorporators are F. R., H. H. and B. W. Henderson. The company is represented by Rose & Paskus, 128 Broadway, New York.

**THE BIG MARIE OIL CO.**, Orange, Tex., has been incorporated with a capital of \$100,000, to manufacture petroleum products. E. C. O'Neal is president, and P. B. Ryan, vice-president, both of Beaumont, Tex.; and C. G. Sprague, Sour Lake, Tex., secretary-treasurer.

**THE STERLING BRICK CO.**, 5201 Twelfth St., Detroit, Mich., has been incorporated with a capital of \$25,000, to manufacture brick and other burned clay products. The incorporators are Harry T. Jenney, E. M. Crider and E. M. Heffron, 5282 Trumbull Ave.

**THE CELLULOSE PLASTICS & CHEMICALS, INC.**, Orange, N. J., has been incorporated with a capital of \$100,000, to manufacture artificial leather and kindred products. The incorporators are E. A. Mau, C. M. Switzer and Oregon Helfrich, 575 Nassau St., Orange.

**B. CANNON & CO., INC.**, Brooklyn, N. Y., has been incorporated with a capital of \$52,000, to manufacture glue, gelatine and kindred products. The incorporators are W. C. Burton, A. Ellis and W. Cunningham. The company is represented by F. J. Knorr, attorney, Albany, N. Y.

**THE BEVERLY CHEMICAL CO.**, Boston, Mass., has been incorporated with a capital of \$25,000, to manufacture chemicals and chemical byproducts. The incorporators are Frank W. and William J. Sullivan, 12 Stoughton St., Medford, Mass. The latter will act as president and treasurer of the company.

**STRONG & CO., INC.**, Wilmington, Del., has been incorporated under state laws, with capital of \$1,500,000, to manufacture refined oil products. The company is represented by the Corporation Trust Co. of America, du Pont Bldg., Wilmington.

**THE W. J. EARLY SONS' FOUNDRY CO.**, Pittsburgh, Pa., has been incorporated with a capital of \$60,000, to manufacture iron, steel and other metal castings. J. E. Early, 812 South St., Pittsburgh, is treasurer.

**THE SCHULZ CHEMICAL CO.**, Brooklyn, N. Y., has been incorporated with a capital of \$10,000, to manufacture chemicals and chemical byproducts. The incorporators are C. Schulz, S. N. Johnson and S. D. Strawgate. The company is represented by J. C. L. Daly, 375 Fulton St., Brooklyn.

**THE SHAW PAPER BOX CO.**, Pawtucket, R. I., has been incorporated with a capital of \$50,000, to manufacture paper boxes and kindred products. The incorporators are William H. M. Moles, Robert S. Emerson and Charles K. Shaw, Pawtucket.

**THE AMERICAN-MEXICAN REFINING CO.**, 11 South LaSalle St., Chicago, Ill., has been incorporated with a capital of \$100,000, to manufacture refined oil products. The incorporators are Henry L. Blim, Norman O. Johnson and D. A. Tasiopoulos.

**THE NYOKALA OIL CO.**, Hamburg (Erie County), N. Y., has been incorporated with a capital of \$500,000, to manufacture refined oil products. The incorporators are G. W. Morris, W. Allen and F. J. Carr. The company is represented by A. L. Stratemeyer, Hamburg, N. Y.

**THE EASTERN STEEL & WIRE CO.**, Newark, N. J., has been incorporated with a capital of \$1,000,000, to manufacture steel and kindred products. The incorporators are John H. Mesiter, R. Notkin and A. MacMillan. The company is represented by Bilder & Bilder, 790 Broad St., Newark.

**THE MEAKIN SOAP CO.**, Pittsburgh, Pa., has been incorporated under Delaware laws, with capital of \$50,000, to manufacture soaps and kindred products. The company is represented by the Capital Trust Co., Dover, Del.

**THE CASTING & SUPPLY CO.**, 239 Washington St., Jersey City, N. J., has been incorporated with a capital of \$50,000, to manufacture iron, steel and other metal castings. The incorporators are J. M. and George M. Bachert, and Herman Traeger.

**THE BRAZOS OIL CORP.**, Houston, Tex., has been incorporated with a capital of \$100,000, to manufacture petroleum products. The incorporators are K. K. Kennedy, T. Lowell Hughes and E. N. Chapman, all of Houston.

**THE WATERTOWN PAPER STOCK CO.**, Watertown, N. Y., has been incorporated with a capital of \$100,000, to manufacture paper products. The incorporators are J. N. and S. Stabins. The company is represented by Pitcher & O'Brien, Watertown.

**THE PURITAN PAINT & COLOR CO.**, Brooklyn, N. Y., has been incorporated with a capital of \$10,000, to manufacture paints, colors, varnishes, etc. The incorporators are W. F. and R. Wolter, and M. Schmidt. The company is represented by Fiero & Fiero, 2 Rector St., New York.

**THE FOREST PAPER CO.**, Portland, Me., has been incorporated with a capital of 5,000 shares of stock, no par value, to manufacture paper products. W. B. Nulty is president, and W. S. Linnell, treasurer. The company is represented by William S. Linnell, Portland.

**THE MAGUIRE TIRE & RUBBER CO.**, Wilmington, Del., has been incorporated under state laws with a capital of \$5,000,000, to manufacture automobile tires and other rubber products. The company is represented by the Corporation Trust Co. of America, du Pont Bldg., Wilmington.

**THE QUEBRACHO PRODUCTS CO.**, New York, N. Y., has been incorporated with a capital of \$50,000, to manufacture tanning extracts and materials. The incorporators are N. A. Randall, F. J. Haley and H. A. Smith, 39 Cortlandt St., New York.

**THE UTILITIES OIL & REFINING CO.**, Mexia, Tex., has been incorporated with a capital of \$150,000, to manufacture refined oil products. The incorporators are F. M. Bransford, E. H. Fielder and H. D. Dines, all of Mexia.

**THE SPEIDEN-WHITEFIELD CO.**, New York, N. Y., has been incorporated with a capital of \$60,000, to manufacture chemicals and affiliated products. The incorporators are E. K. Speiden, L. M. Whitefield and A. E. Adams. The company is represented by A. Simmers, 95 Liberty St., New York.

**THE ALINALL MFG. CO.**, Worcester, Mass., has been incorporated with a capital of \$24,000, to manufacture paints, colors, etc. Everett H. Hall is president; M. G. Allen, vice-president; and Walter B. Allen, Worcester, treasurer.

**THE GROESBECK STANDARD BRICK CO.**, Groesbeck, Tex., has been incorporated with a capital of \$40,000, to manufacture brick, tile and other burned clay products. The incorporators are E. Raphael and Joseph Jolesch, both of Groesbeck.

**THE ECONOMY INK TONING CORP.**, Valley Stream (Nassau County), N. Y., has been incorporated with a capital of \$10,000, to manufacture inks, chemicals and affiliated products. The incorporators are M. I. and J. Kahn. The company is represented by Alexander Rosenbaum, 233 Broadway, New York.

**THE STRUCTURAL GYPSUM CORP.**, Jersey City, N. J., has been incorporated with a

capital of \$1,125,000, to manufacture gypsum products. The company is represented by the Registrar & Transfer Co., 15 Exchange Pl., Jersey City.

**THE CALTEX OIL CO.**, San Antonio, Tex., has been incorporated with a capital of \$80,000, to manufacture petroleum products. The incorporators are H. L. Schermerhorn, A. D. Cummings and J. F. Carl, all of San Antonio.

**THE JACKSONVILLE CHEMICAL CO.**, New York, N. Y., has been incorporated with a capital of \$25,000, to manufacture chemicals and chemical byproducts. The incorporators are N. Sacks, A. Rosenthal and H. C. Lindgren. The company is represented by Joseph Schottland, 160 Broadway, New York.

**THE UNIQUE OIL CO.**, Wilmington, Del., has been incorporated under state laws with capital of \$1,000,000, to manufacture refined oil products. The company is represented by the Corporation Service Co., Wilmington.

**THE LAMOLE PRODUCTS CORP.**, New York, has been incorporated with a capital of \$20,000, to manufacture chemicals, dyes, etc. The incorporators are M. Lake, A. S. Molnar and O. S. Leazay, 319 East 24th St.

**THE CHATHAM CHEMICAL CO.**, Savannah, Ga., has been incorporated with a capital of \$150,000, to manufacture fertilizer products. The incorporators are George E. Cope, Gordon L. Grover and W. B. Stratford, all of Savannah.

## New Publications

### BOOKS

**A LIFE OF GEORGE WESTINGHOUSE.** By Henry G. Prout, C.E., A.M., LL.D. 375 pp., illustrated. New York: Charles Scribner's Sons, 1922. Price, \$2.50.

This life of George Westinghouse is the second in what may be a series of biographies of great men associated with the American Society of Mechanical Engineers. Mr. Westinghouse left no written record except in the files of his numerous companies. He wrote almost no private letters. He kept no journals or even notebooks. He made but few addresses and wrote few papers. Accordingly it was necessary to draw upon the many men still living and working who were close to Westinghouse. It was the duty of Mr. Prout as editor to digest these contributions, to co-ordinate them, and to keep a reasonable perspective. In this he was aided by the committee of the American Society of Mechanical Engineers appointed for that purpose: Charles A. Terry, chairman; Paul D. Crayth, Alexander C. Humphreys, James H. McGraw, Charles F. Scott, Lewis B. Stillwell, Ambrose Swasey, with Henry Herman Westinghouse always in consultation.

Mr. Westinghouse's activities were so varied that a chronological narrative would of necessity lead to some confusion. For this reason, each topic has been treated by itself and one has but to glance at the chapter headings to realize the tremendous activity and breadth of vision of this great pioneer. The air brake and friction draft gear naturally take first place, followed by the electrical and related activities—the induction motor and meter, the rotary converter, lighting, power transmission, electric traction, steam and gas engines, the turbo-generator, signaling and interlocking. Natural gas and other interests are considered in separate chapters. There are also general chapters on the European enterprises, financial methods, personality and meaning of George Westinghouse. In an appendix are given chronological and classified lists of his patents.

**TRANSACTIONS OF THE AMERICAN ELECTRO-CHEMICAL SOCIETY**, vol. 38. 462 pp., illustrated. Published by the American Electrochemical Society at the office of the secretary, Lehigh University, Bethlehem, Pa. Price, \$3 to non-members, \$2.50 to members, \$2 to libraries, colleges, etc.

This volume contains the papers presented at the thirty-eighth general meeting, Cleveland, Sept. 30, Oct. 1, 2, 1920.

**THE MINERAL INDUSTRY DURING 1920.** Vol. 29. Edited by G. A. Roush, A.B., M.S., associate professor, department of metallurgy, Lehigh University. 907 pp., illustrated. New York: McGraw-Hill Book Co., 1921. Price, \$10.

Statistical, technical and commercial data for 1920 are given for the following: Abrasives, aluminum and bauxite, antimony, arsenic, asbestos, asphalt, barium and strontium, bismuth, borax, bromine and iodine, cadmium, cement, chromium, coal and coke, cobalt, copper, cryolite, feldspar, fluorspar, fullers earth, gold and silver, graphite, gypsum, iron and steel, lead,

magnesite, manganese, mica, molybdenum, monazite, nickel, petroleum and natural gas, phosphate rock, platinum, potash, precious stones, quicksilver, radium, selenium and tellurium, sodium salts, sulphur, pyrite and sulphuric acid, talc and soapstone, tin, titanium and zirconium, tungsten, uranium and vanadium, zinc. The book also includes a chapter on ore dressing and coal washing, and a supplementary chapter of mineral statistics.

**STUDY QUESTIONS IN ELEMENTARY ORGANIC CHEMISTRY.** By *Alexander Lowy, Ph.D.*, assistant professor of organic chemistry, University of Pittsburgh and *Thomas B. Downey, M.S.*, instructor in organic chemistry, University of Pittsburgh. 91 pp. New York: D. Van Nostrand Co., 1921. Price, \$1.

The study questions in this book are divided into forty-five groups covering the entire field of a general elementary course in organic chemistry. They are designed to aid the students in mastering the subject more thoroughly, and have been used for this purpose with marked success at the University of Pittsburgh. An excellent bibliography of works and periodicals on pure and applied organic chemistry suggests material for collateral study.

**OIL SHALES.** By *H. B. Cronshaw, B.A., Ph.B., A.R.S.M.* 80 pp. with map. London: John Murray, 1921. Price, 5s.

This is one of the series of monographs on mineral resources with special reference to the British Empire prepared under the direction of the Mineral Resources Committee of the Imperial Institute with the assistance of the scientific and technical staff. After discussing the occurrences, characteristics and uses of oil shales in a general way, the sources of supply are considered in more detail, one chapter being devoted to the British Empire and another to foreign countries. Then follow a world map showing the location of oil shale districts and six pages of references to the literature on oil shales.

**THE DESIGN OF STEEL MILL BUILDINGS AND THE CALCULATION OF STRESSES IN FRAMED STRUCTURES**, fourth edition, rewritten. By *Milo S. Ketchum, C.E.*, director of the department of civil engineering, University of Pennsylvania. 632 pp., 60 tables, 410 illustrations. New York: McGraw-Hill Book Co., 1921. Price, \$6. This book covers the calculation of the stresses in framed structures, and also the design of buildings having a self-supporting steel frame with a light covering, usually fireproof. In this edition the book has been rewritten and enlarged, the type has been reset and the plates have been recast. The scope of the book has been enlarged by the addition of a concise discussion of the calculation of the stresses in statically indeterminate trusses and frames, several problems in framed structures and detailed designs of a crane girder, a roof truss, and a steel frame mill building. The book is written to serve as a text book in structural engineering and also as a book of reference for engineers. A complete specification for steel frame mill buildings is given in an appendix.

**LABORATORIES: THEIR PLANNING AND FITTINGS.** By *Alan E. Munby, M.A., F.R.I. B.A.* 226 pp., 165 illustrations. New York: D. Van Nostrand Co., 1921. Price, \$6.

Literature on the subject of laboratories is surprisingly incomplete and scattered. Indeed, the author states in the preface that "search has not revealed any work now in print published in this country [England] which endeavors to deal with laboratories in a manner calculated to bring a building committee, a professional staff and an architect on common ground for what is essentially a joint undertaking." The volume opens with a historical introduction by Sir Arthur E. Shipley, ex-vice chancellor of Cambridge University. The subject is then treated by topics as follows: Scope and Inception of Building Schemes; Requirements of Chemistry; Requirements of Physics; Requirements of Biology and Geology; Laboratory Services; Recent Designs. Excellent descriptions and detailed drawings of typical laboratories in England, the United States and on the Continent make the book of great practical value to those interested in the design construction and equipment of laboratories.

**ELEMENTARY CHEMICAL MICROSCOPY**, second edition, partly rewritten and enlarged. By *Emile Moynin Chamot, B.S., Ph.D.*, professor of chemical microscopy and sanitary chemistry, Cornell University. 479 pp., 162 illustrations. New York: John Wiley & Sons, Inc., 1921. Price, \$4.25.

This book is intended to serve as an introduction to the microscope and its accessories as tools for the chemist to work with and even though practical applications are referred to, the author has made no

effort and has no desire to have the book take the form of a manual of industrial microscopy. The changes in this edition have been chiefly in the rearrangement of the chapters, in the elaboration of the data presented and in the rewriting of obscure passages. Comparatively little new apparatus has been described or new methods introduced. A brief synopsis of the course in introductory chemical microscopy as now given at Cornell University has been inserted in the appendix.

In order to meet the often expressed needs of advanced students and of professional chemists, a Handbook of Microscopic Qualitative Analysis is in preparation which will be copiously illustrated by microphotographs and which will thus serve to supplement the present introductory text.

**CHEMICAL AND METALLOGRAPHIC EXAMINATION OF IRON, STEEL AND BRASS.** By *William T. Hall*, associate professor of analytical chemistry, Massachusetts Institute of Technology, and *Robert S. Williams*, associate professor of analytical chemistry and metallography, Massachusetts Institute of Technology. 501 pp., 182 illustrations. New York: McGraw-Hill Book Co., 1921. Price, \$5.

This volume of the International Chemical Series by the translators of Bauer and Deiss's "Sampling and Analysis of Iron and Steel" is divided into two parts.

Part I covers the chemical analysis of iron, steel and brass, and includes the determination of the following elements in iron and steel: C, Mn, P, Si, S, Cu, Cr, Fe, Ni, Mo, W, V, Al, As, Ti, N, O, Zr. A chapter is devoted to the electrometric methods applicable to iron and steel analysis and this part of the book closes with two chapters on the analysis of non-ferrous alloys.

Part II deals with the application of metallography to the inspection and sampling of alloys. The topics are as follows: Preparation and Examination of the Specimen; Metallographic Constituents of Iron and Steel; Wrought Iron and Steel; General Study of Steel With the Microscope; Metallographic Examination of Iron; Gray Iron; Sampling of Iron and Steel; the Alloys of Copper.

**A MANUAL OF FLOTATION PROCESSES.** By *Arthur F. Taggart*, professor of ore dressing, Columbia University. 181 pp., 56 illustrations. New York: John Wiley & Sons, Inc., 1921. Price, \$3.

As indicated by the title, this book attempts to review the entire field of flotation. Its purpose is, in part, to counteract the further spread of false conception concerning flotation concentration, by setting forth some of the essential facts which contradict them; in part to describe apparatus and methods of testing which will aid investigators in their own researches; finally, to give some generalizations from mill practice, by means of which the laboratory experimenter can translate his results into commercial operations. The four chapters of the book are: Introduction, Testing Laboratory Equipment, Testing, Mill Data.

**ELECTRODEPOSITION AND ELECTROPLATING.** A General discussion held at Sheffield, November, 1920. Reprinted from the *Transactions of the Faraday Society*, vol. 46, part 3, 1921. 83 pp. Published by the Faraday Society, 82 Victoria St., London, S. W. Price, 10s. 6d.

This is a reprint of papers and general discussion presented at a symposium on the subject held by the Faraday Society. The following papers are included: "Electroplating for the Prevention of Corrosion," by Leslie Aitchison; "Some Applications of Electrodeposition in Aeronautical Engineering," by W. H. Thain; "Electrodeposition of Cobalt," by Byron Carr; "Commercial Electrolysis of Zinc Sulphate Solutions," by Samuel Field; "Deposition of Gold-Silver Alloys," by Samuel Field; "Use of Colloids in the Electrodeposition of Metals," by W. E. Hughes; "Electro Silver Plating: Its Technical Development," by W. R. Barclay; "The Chemical Composition of Old Silver Plating Solutions," by G. B. Brook; "A New Maximum Current Density in Commercial Silver Plating," by Frank Mason; "The Crystalline Structure of Electrodeposited Silver," by G. B. Brook.

**PROCEEDINGS OF THE AMERICAN SOCIETY FOR TESTING MATERIALS**, vol. 21, 1921. 1,197 pp. Published by the Society, 1315 Spruce St., Philadelphia, Pa.

This volume contains the proceedings of the twenty-fourth annual meeting, held at Asbury Park, N. J., during June, 1921, a meeting which was reported in *CHEMICAL & METALLURGICAL ENGINEERING* for June 29, 1921 (vol. 24, p. 1,145). It contains 444 pages devoted to the reports of committees. Four hundred pages are devoted to nearly 100 tentative standards, proposals printed for one or more years, with a view of eliciting criticism. Many of these have

to do with methods of testing, the most elaborate being for methods of analysis of aluminum and its light alloys. Another long specification concerns rubber-insulated wire. The remainder of the book contains the technical papers read and discussed.

## Manufacturers' Catalogs

**PENNSYLVANIA PUMP & COMPRESSOR CO.**, Easton, Pa., has issued Form 102, superseding Form 101, on Pennsylvania air compressors and vacuum pumps, both power- and steam-driven in straight-line, single-stage types. The Pennsylvania construction is described in detail and illustrations are given. Copies will be sent on request.

**THE CALORIZING CO.**, Pittsburgh, Pa., in a 4-page booklet describes Calite castings for use in high temperatures, and also its characteristics and physical properties. The General Electric Co.'s research engineers have spent many years to get this alloy, which is claimed to stand high heat.

**SCHUTTE & KOERTING CO.**, Philadelphia, Pa., has just issued a new catalog on heat-transfer equipment. This book contains Bull. 10 DE, on evaporators, heaters and distillers; Bull. 10 F, on heaters for water and fuel oil; Bull. 11 T, on Thermofan system for heating ships; Bull. 12 C, on heat exchangers for recooling oil; Bull. 12 G, on heaters and coolers for air and gases; Bull. 12 R, on multitube motor radiators. Each is descriptive, and well illustrated. This is a reference volume which should be valuable to any plant engineer who is interested in heat transfer as applied to fuel oil systems, heating liquids, feed water, etc.

**THE BETHLEHEM FOUNDRY & MACHINE CO.**, Bethlehem, Pa., calls attention to an attractive catalog on chemical equipment of metal. Illustrations and descriptive matter are given on nitraters, sulphurators, reducers, vacuum stills, washers, autoclaves, etc.

**THE ATERTITE CO., INC.**, Paterson, N. J., in Bull. 8 describes and illustrates Aterite and Fanosite valves, cocks, fittings and specialties for manufacturers and users of chemicals.

## Coming Meetings and Events

**AMERICAN CERAMIC SOCIETY** will hold its twenty-fourth annual meeting at St. Louis, Feb. 27 to March 3, 1922.

**AMERICAN CHEMICAL SOCIETY** will hold its spring meeting at Birmingham, Ala., April 4 to 7, 1922.

**AMERICAN ELECTROCHEMICAL SOCIETY** will hold its spring meeting in Baltimore, April 27, 28 and 29, 1922.

**AMERICAN FOUNDRYMEN'S ASSOCIATION** will hold its next convention and exhibit at Cleveland, O., during the week of April 24, 1922. Meetings will be held in the spring instead of in the fall as heretofore.

**AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS** will hold its spring meeting in New York the week of Feb. 26, 1922.

**AMERICAN WOOD PRESERVERS ASSOCIATION** will hold its annual meeting Jan. 24, 25 and 26 at the Hotel Sherman, Chicago, Ill.

**NEW JERSEY CHEMICAL SOCIETY** holds a meeting at Stettin's Restaurant, 842 Broad St., Newark, N. J., the second Monday of every month.

**STAMFORD CHEMICAL SOCIETY**, Stamford, Conn., holds a meeting in the lecture room of the local high school on the fourth Monday of each month, except June, July, August and September.

The following meetings are scheduled to be held in Rumford Hall, the Chemists' Club, New York: Feb. 10—American Electrochemical Society (in charge), Société de Chimie Industrielle, American Chemical Society, joint meeting; March 10—American Chemical Society, Nichols Medal; March 24—Society of Chemical Industry, regular meeting; April 21—Society of Chemical Industry (in charge), American Electrochemical Society, Société de Chimie Industrielle, American Chemical Society, joint meeting; May 5—American Chemical Society, regular meeting; May 12—Société de Chimie Industrielle (in charge), American Chemical Society, Society of Chemical Industry, American Electrochemical Society, joint meeting; May 19—Society of Chemical Industry, regular meeting; June 9—American Chemical Society, regular meeting.